Holt Instrument Laboratories

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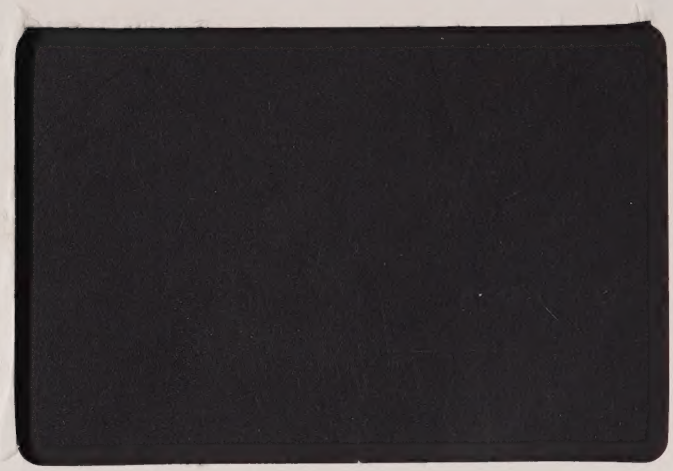
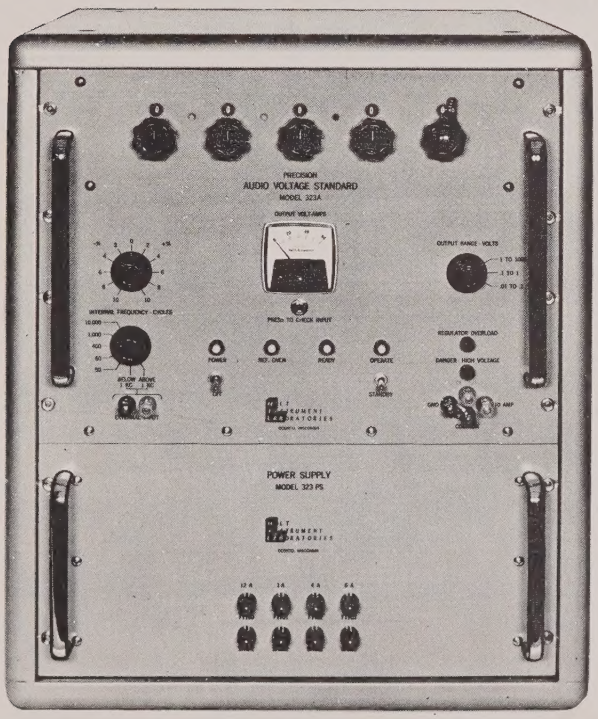
DESIGNERS & MANUFACTURERS OF ELECTRONIC INSTRUMENTATION



OPERATING AND SERVICING MANUAL FOR AUDIO VOLTAGE STANDARD MODEL 323A



THIS MANUAL TO ACCOMPANY

INSTRUMENT NO. _ _ _ _ _

APRIL 1964

HOLT INSTRUMENT LABORATORIES

OCONTO, WISCONSIN

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CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or it is damaged in any way, a claim should be filed with the carrier. Also, notify Holt Instrument Laboratories or the local representative immediately. A full report of the damage should be obtained by the claim agent and this report should be forwarded to us. We will advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Holt Instrument Laboratories warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Batteries and thermocouples are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid, and when upon our examination it is to our satisfaction defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify either the factory or the area Holt representative, giving full details of the difficulty, and include the model and serial numbers. Upon receipt of this information we will give you service data or shipping instructions.

2. On the receipt of shipping instructions, forward the instrument prepaid to the factory or the authorized repair station indicated in the instructions. If requested, an estimate of the charges will be made before the work begins if such work is not covered by warranty. All shipment of Holt Instrument Laboratories' equipment should be packed in a strong exterior container surrounded by two or three inches of shock absorbing material.

ADDENDUM: Model 323A Manual

Page 3-5

Paragraph 3.4

f. The quiescent currents of V506 and V507 are adjusted by the output bias control (R554). These tubes are matched for quiescent currents within a 10 ma range for a given bias voltage. A frequency selective network consisting of C520, C521, C522, R545, R546 and R547 passes a signal proportional to load from the current sensing transformer (T101) at output frequencies below 200 cps and above 10 KC only. These signals are rectified and cause Q500 to conduct. Conduction of Q500 causes the output bias voltage to go more positive, which, increases the quiescent current in V506 and V507 and minimizes the full load distortion.

ADDENDUM Model 323A - S/N 15155 and Subsequent 6-20-66

Paragraph 3.9 d. Page 3-8 Delete and replace with the following:

d. The zener bridge circuit is the source of the reference voltage and its stability determines the accuracy of calibration of the Model 323A. The zener reference diode is carefully selected and aged over a ninety day period to insure its long term stability. The bridge circuit is carefully balanced with a current of approximately 1 milliampere flowing in the center arm. Resistor (R1009) adjusts the reference voltage to the correct level as determined in the One Volt Output Calibration in the Recalibration Procedure, Pg. 4-2. The reference voltage may be between 4.98 VDC and 5.02 VDC as read at the center arm of R405. The bridge is balanced for minimum noise by adjusting resistor (R1011). This is not a field adjustment.

Paragraph 4.2 c. Page 4-1 Delete and replace with the following:

c. Reference Voltage Calibration. No calibration of the reference voltage is normally required. However, if it is impossible to obtain the One Volt Output Calibration as described in 4.2 d., and if it has been determined that the unit is in all other respects operating correctly, then the reference voltage can be calibrated as follows:

Remove the reference pack top cover and note the access hole in the top of the insulation covering the oven assembly. If the hole is not provided remove this piece of insulation and with a sharp tool make a small hole to correspond with the adjustment screw of R1009, the trim pot, located closest to the connector on the resistor assembly board.

CAUTION

Do not confuse R1009 with the trim potentiometer (R1011) located nearby. R1011 is set at the factory and requires no further adjustment. Under NO conditions should R1011 be tampered with. R1011 is used to balance the bridge including the reference element, and it is peculiar to that particular reference element. Misadjustment will affect both the noise and the reference voltage level.

To adjust the reference pack output voltage turn R405 to the center of its travel. Adjust R1009 to obtain 5.000 VDC $\pm$ 0.05% at the center arm of R405.

ADDENDUM: Model 323A Manual

Page 4-1

Paragraph 4.2

a. Power Amplifier Distortion. The output bias control (R554) must be adjusted before making distortion measurements. Make this adjustment with the Model 323A in "Standby". Set the output bias control (R554) to give 8.5 VDC across R544. Measure the voltage across R543, which must be 8.5 $\pm$ 0.8 VDC. The output bias control (R554) may be readjusted within the range of 8.0 VDC to 9.0 VDC across R544 to minimize full load distortion. The distortion may be measured by using either a total harmonic distortion analyzer or a wave analyzer. The latter is preferred because it allows the adjustment of the balance control (R514) without momentarily over-driving the analyzer. When measuring distortion, set the output of the Model 323A to 99.9 volts with a 30 watt load. Select a frequency of 1 kc from the internal oscillator. Adjustment of the balance control (R514) will reduce the total harmonic distortion by minimizing the even harmonic component.

SECTION 1
INTRODUCTION

1.1 General Description

a. The Holt Audio Voltage Standard, Model 323A is an extremely stable, self-regulated, calibrated source of audio frequency voltage. Its primary function is to act as a precision source of continuously variable sine wave voltage for use in the calibration of other instrumentation.

b. The Model 323A can supply voltages from 10 millivolts to 1000 volts with essentially infinite resolution. The voltage appearing at the output terminals is extremely stable and is indicated on in-line digital readout immediately above the voltage selector switches.

c. The Model 323A provides a frequency range of 35 to 20,000 cycles. An internal oscillator supplies five customer selected frequencies, variable ± 10% in 2% increments. Any external variable frequency source of approximately one volt RMS, such as the Holt Model 448 Audio Oscillator, will enable the unit to provide continuously variable frequency output over the above voltage and frequency ranges.

d. Although the Model 323A was designed primarily as a secondary calibration standard, its power handling capability of 30 voltamperes enables it to be used for many other applications. It can, for instance, calibrate many instruments at one time. It can be used with a transfer standard such as the Holt TV1 to obtain accuracies approaching those of DC measurements. Used in conjunction with an accurate AC voltmeter, it can act as a source for testing transformers, capacitors, and inductors since it is virtually insensitive to reactive loads. The ease with which various voltages and frequencies can be dialed make the Model 323A an ideal voltage source for the frequency response testing of amplifiers and filters.

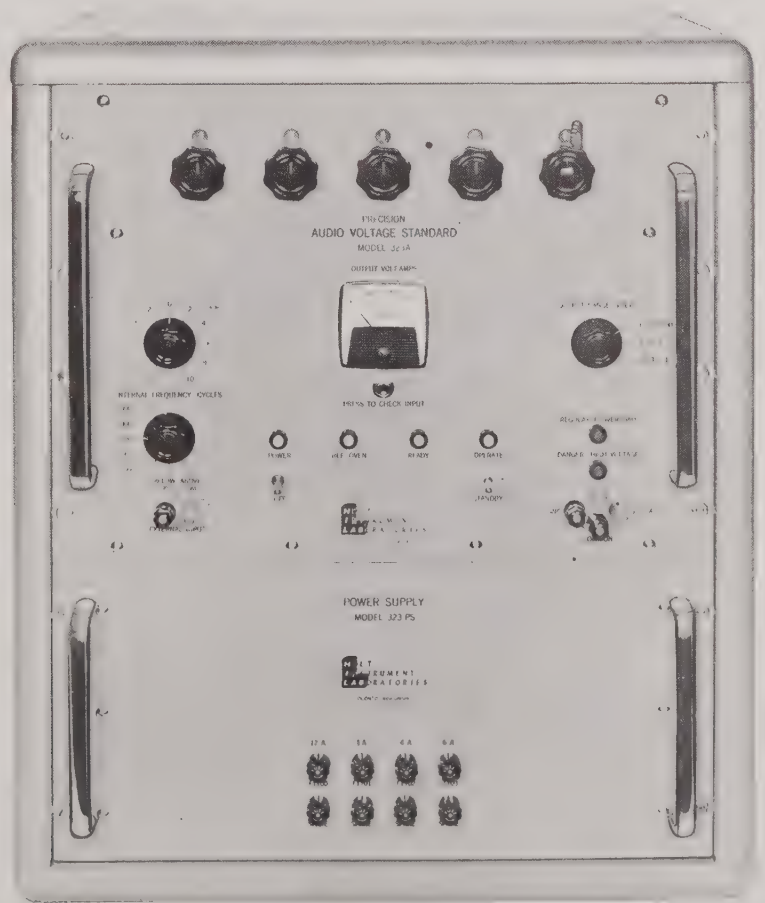


Figure 1. Audio Voltage Standard - Model 323A

TECHNICAL SPECIFICATIONS

VOLTAGE RANGE:

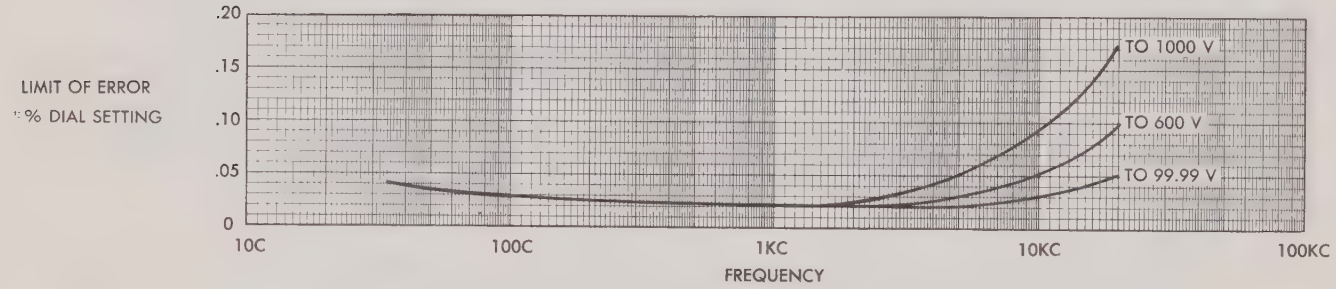
Continuously adjustable by 5 decade switches and a vernier potentiometer.

Range:	Dial resolution:
0.01 V to 0.1 V	2 micro V per division
0.1 V to 1 V	20 micro V per division
1 V to 1000 V	200 micro V per division

ABSOLUTE RMS VOLTAGE ACCURACY - NO LOAD: Stated as maximum limit of error (±% of dial setting), including all contributing errors and uncertainties.

Internal Oscillator at:	50, 60 cps	400 cps	1 KC	10 KC
To 99.999 volts	.035	.025	.020	.035
To 600.000 volts	.035	.025	.020	.050
To 1000.000 volts	.035	.025	.020	.090

For use with external oscillator, refer to curve below:



STABILITY:

Long term Calibration (60 days) 1.	± .02%
Short term amplitude (random) 2.	± .01%
Beat frequency modulation (near line freq.)	± .10%

FREQUENCY RANGE:

External oscillator:

35 cycles to 20 KC. (When using an external oscillator, the Model 323A specifications, especially voltage stability and output distortion, are primarily dependent upon the corresponding oscillator specifications.)

Internal oscillator:

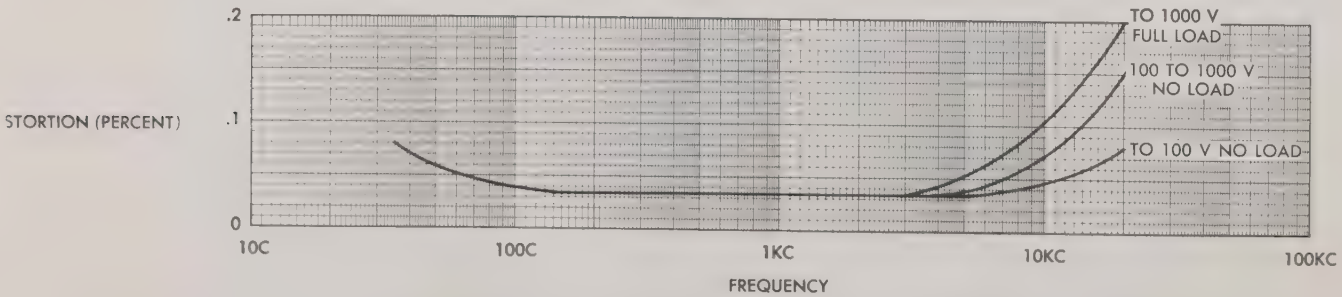
Any 5 fixed frequencies between 35 cycles and 20 KC. Standard frequencies are 50C, 60C, 400C, 1 KC and 10 KC. Each frequency is variable ±10% in approximately 2% steps. Frequency Calibration: ±0.5% after 30 minute warmup. Frequency Stability: ±0.1% per hour after 30 minute warmup.

OUTPUT DISTORTION:

Waveform:

Sinusoidal.

Total harmonic distortion: (When using internal oscillator)



SPECIAL 1 VOLT OUTPUT:

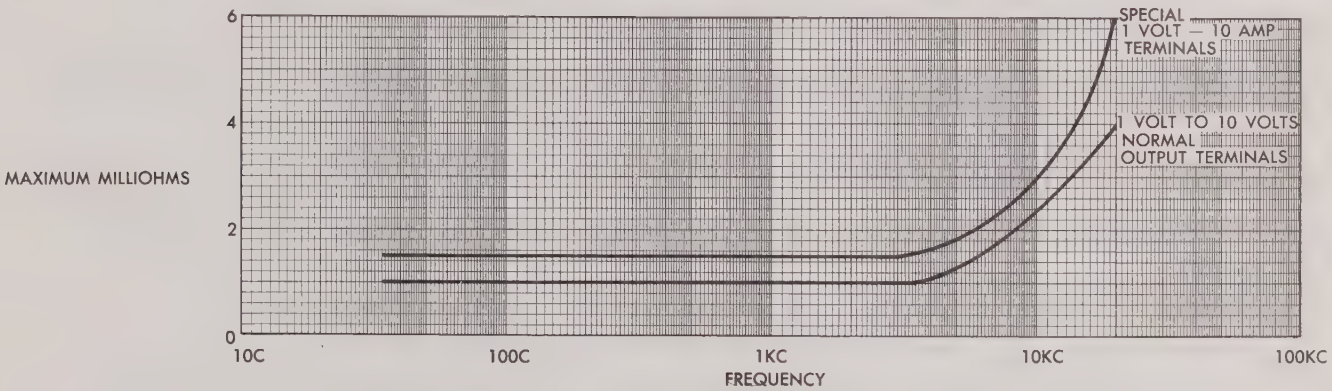
No load calibration:
±0.5%
10 amperes maximum.
Special 1 volt - 10 ampere output terminals provide a high current source for the calibration of wattmeters and ammeters.
For details, see Application Notes on next page.

OUTPUT LOAD REGULATION:
(No Load to Full Load)

10 volts to 1000 volts:
.01% maximum to 10 KC.
.03% maximum to 20 KC.
Below 10 volts:
Depends on load current, output voltage and output impedance stated below.

OUTPUT IMPEDANCE:

Below 1 volt:
150 milliohms maximum.
1 volt to 10 volts:



MAXIMUM OUTPUT POWER:

Below 1 volt:
0.5 amperes maximum.
1 V to 10 V:
3 amperes maximum.
10 V to 500 V:
30 volt-amperes or 1 ampere maximum, whichever is less.
Above 500 volts:
to 6 KC 30 volt-amperes.
to 20 KC 20 volt-amperes.

LOAD METER:

Range:
0 to 60 volt-amperes.
Accuracy:
±10%.

SIZE:

Regulator:
19" W x 14" H x 15" D.
Power supply:
19" W x 8¾" H x 16" D.

WEIGHT:

Regulator:
Approximately 90 lbs.
Power supply:
Approximately 90 lbs.

INPUT POWER:

115V/220V ±10%, 50 - 60 cycles, 750 watts.

NOTES:

1. Holt Laboratories feels that good practice requires a periodic test (with NBS traceable test instruments) of any standard, such as the Model 323A, that is used to calibrate other instruments. We recommend a check every 60 days. Experience indicates that calibration adjustment normally is not necessary, but should it be required, the Model 323A has adjustable reference to permit setting to specified accuracy.

2. When using internal oscillator. This stability permits reading a 5-digit DVM plus or minus one on the least significant digit.

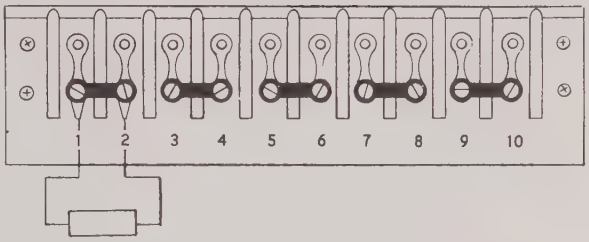
SECTION 2
OPERATING INSTRUCTIONS

2.1 Preparation for Use

a. General. The Audio Voltage Standard is supplied, factory tested and calibrated, in two shipping containers. The customer need only place the two units in position and connect the power cable between them. It requires no preliminary service by the customer other than inspection to be sure all tubes are seated and all plugs and connectors are tight.

b. Power Connections. The power cord is terminated in a three prong, polarized male connector. Connect the large rectangular pin to the common side of the AC power line and the small rectangular pin to the hot side of the line. The large round pin of the connector is wired directly to the chassis of the instrument. It is important that this pin be connected directly to a good earth ground connection. Large amounts of noise or 60 cycle voltage on the instrument chassis may affect the regulation. Be sure the power switch is off before inserting line plug.

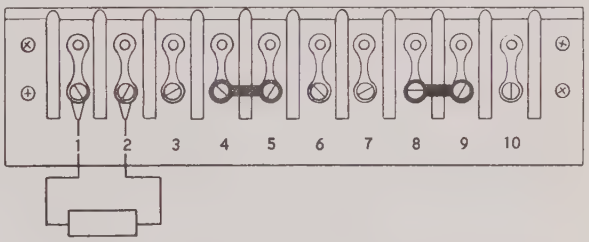
c. Power Line Voltage. The instrument is designed for operation on power lines of either 115 or 230 volts ± 10%. Check the transformer connections and the line fuses to be sure they correspond to those in figure 2 for the particular line voltage to be used. The fuses are located on the front panel of the power supply (fig. 4). The transformer connections are located on the back of the power supply chassis (fig. 22).



F1100 - 12 AMP F1102 - 4 AMP

F1101 - 1 AMP F1103 - 3.2 AMP

115 VOLT CONNECTIONS



F1100 - 6 AMP F1102 - 2 AMP

F1101 - 1 AMP F1103 - 1.6 AMP

230 VOLT CONNECTIONS

Figure 2. Power Supply Connections

d. Operating Temperatures. The Model 323A and its power supply are each equipped with fans to circulate air and prevent overheating. If the unit is enclosed in a rack or cabinet, provision must be made for adequate circulation of air to keep the internal temperatures below 50 degrees C. The voltage reference zener and the internal oscillator thermistors are regulated in ovens. Any condition that will cause the ovens to lose control will alter the output of the unit. The six volt supply regulator heat sink is protected by a thermostat that will shut down the unit in the event of overheating. Any excessive rise in temperature may cause this protective device to open.

2.2 Operating Controls and Indicators

The controls, indicator light, terminals, and fuses located on the front panel are described below. These are the controls used in the normal operation of the Audio Voltage Standard. The internal controls and adjustments used in calibration and adjustment of the instrument are covered in the appropriate maintenance section.

a. Power Switch. In the POWER position, this switch applies power to the heaters and oven immediately and also to a 30 second time delay relay. At the completion of the time delay period, the plate voltage is automatically turned on. The unit is now in standby position ready for use.

NOTE

Although the unit is ready for use at the end of the 30 second time delay period, a warmup period of 30 minutes will allow the ovens to reach a stabilized temperature resulting in improved accuracy and stability.

b. Power Indicator Light. When lit, indicates that power is applied to the unit.

c. Ready Light. When lit, indicates that the 30 second time delay is completed and plate power is applied to the unit. The unit is ready for operation.

d. Standby Switch. In the STANDBY position, this switch turns off the chopper and control amplifier and effectively shorts out the input signal at the input to the amplifier. All other circuits are warmed up with plate voltage applied. In the OPERATE position, the chopper and control amplifier are turned

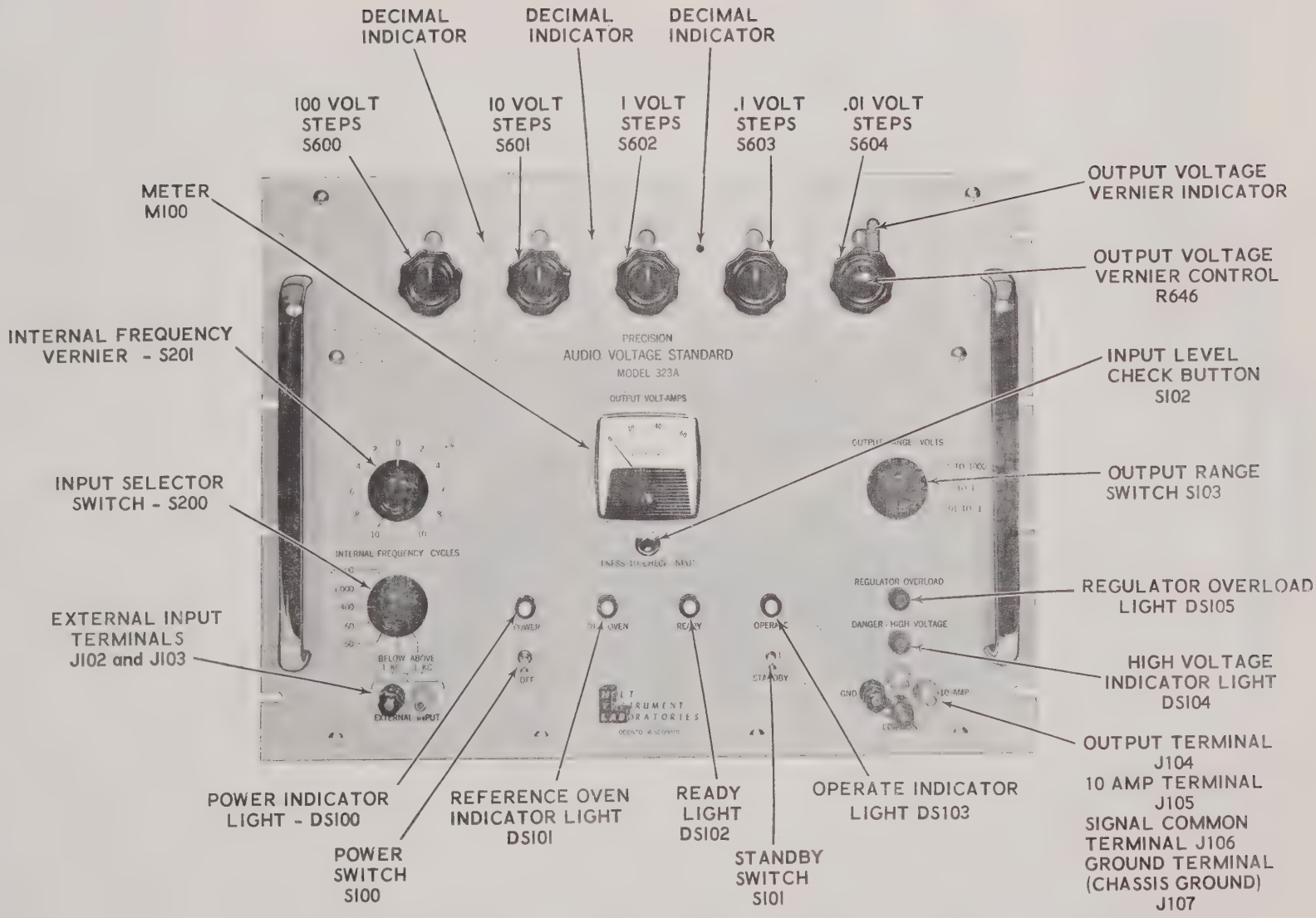


Figure 3. Operating Controls and Indicators

on and input signal is applied to the amplifier.

e. Operate Indicator Light. When lit, indicates the standby switch is in the OPERATE position and the unit is operating.

f. Input Selector Switch. This seven position rotary switch enables the operator to select any one of five internal frequencies or to connect the amplifier to the external oscillator terminals. The internal frequencies are:

(1) 10,000 cps.

(2) 1,000 cps.

(3) 400 cps.

(4) 60 cps.

(5) 50 cps.

NOTE

The frequencies listed above are the stock frequencies supplied by the factory. Special frequencies are optional at extra cost.

Two positions are provided for connection to the external oscillator terminals. They are marked:

(6) BELOW 1 KC.

(7) ABOVE 1 KC.

Select the proper position depending on the frequency in use.

Two positions are provided so that the proper output transformer will be selected internally, since the output transformers have been specially designed for optimum performance above or below the 1 KC dividing point.

g. Internal Frequency Vernier. This eleven position rotary switch enables the operator to vary the internal oscillator frequency 10 percent above or 10 percent below the frequency selected by the Internal Selector Switch. The switch is arranged to allow changes in increments of 2 percent.

NOTE

The specified frequency range of Model 323A is 35 to 20,000 cycles per second. If a customer orders special frequencies for the input selector switch that are above 18,000 or below 40 cps, the ± 10% range of the Internal Frequency Vernier would require operation of the Model 323A outside its specified range.

h. Input Level Check Button. Pressing this button enables the operator to quickly determine if the input level to the amplifier is of sufficient amplitude to operate the unit. The input level is indicated on the front panel meter when the button is pressed. For proper operation, the needle should fall on the green calibrated section of the meter scale marked INPUT SET.

i. Output Range Switch. The three position Output Range Switch enables the operator to select the range of output voltages to be supplied and also changes the decimal point on the digital readout indicator. The output voltage ranges are:

(1) 1 to 1,000 volts.

(2) .1 to 1 volt.

(3) .01 to .1 volt.

j. Output Voltage Controls. The five large knobs across the top of the panel, along with the center vernier knob on the top right hand control knob, make up the output voltage controls. Each of the main control knobs rotates a ten position switch and also changes the number on its corresponding digital readout window. The vernier dial controls a slide wire potentiometer and rotating dial indicator, a combination that makes available almost infinite resolution of the output voltage.

Selection of an output voltage is a two-step procedure:

(1) Select the output voltage range using the range switch. This will automatically set the decimal point on the readout.

(2) Select the desired output voltage by dialing the value with the five voltage selection knobs and the vernier while watching the readout indicators.

NOTE

BE SURE TO DIAL THE CORRECT OPERATING RANGE. Do not attempt to obtain .8 volt by setting the range switch to 1 to 1,000 volts and setting the selector switches to 000.8. The internal circuitry of the unit requires that voltage less than 1 volt and .1 volt be determined by changing the range switch and moving the decimal point.

k. Reference Oven Indicator Light. The reference oven is thermostatically controlled to insure an even temperature and thus stabilize the voltage calibration of the unit. The reference oven indicator light is lit each time the oven heater is turned on. Normal operation is indicated when this light cycles on and off. If the light stays on or off for a long period, the reference oven is not functioning properly and the reference voltage may no longer meet specifications.

l. Regulator Overload Light. Under normal operating conditions, this light will remain off. The regulator overload light is on only when the control loop is not balanced and the output voltage is incorrect. This may occur when the output voltage or frequency is changed and the control amplifier and input regulator are correcting for the new conditions. When the correct output voltage is established, the light will go out. The light will also come on if the input voltage from the external oscillator drops below operating level. If the light stays on, some unbalance is indicated and must be corrected before using the unit.

m. High Voltage Indicator Light. This indicator light is lit whenever the output voltage is set above 100 volts. Voltages as high as 1,000 volts are available at the output terminals. This light serves as a warning not to touch the terminals while dangerous voltages are present.

n. Input Terminals. Whenever frequencies other than the five internal frequencies are to be used and external oscillator is connected to these terminals, use of a high quality oscillator (such as the HOLT Model 448) is recommended. Input level may be checked with the Input Level Check Button. See h. above.

o. Output Terminals. The output terminals consist of a group of four terminals, two black and two red. They are labeled on the panel as follows:

(1) GND - Black terminal connected to chassis ground.

(2) COMMON - Black terminal connected to the signal common in the unit. The signal common is floating within the unit. The only connection between signal common and chassis is the strap between the COMMON and GND terminals. With the strap removed, the common will float.

(3) OUTPUT - Red terminal to which is connected the calibrated output of the unit.

(4) 10 AMP - Red terminal which delivers 10 amperes at 1 volt. This is a nominal 1 volt output. If a calibrated 1 volt is required, use the OUTPUT terminal. Principal application of this terminal is in calibration of wattmeters or current devices using an accurate ammeter as a standard.

p. Meter.

(1) The front panel meter is connected directly to the output circuit and reads the output voltamperes. Full load on the unit is 30 voltamperes. At the higher frequencies, when using the high voltage output, the meter will show some load even with no connection to the unit. This reading is the voltampere load of the internal wiring and is normal.

(2) Pressing the input level check button under the meter switches the meter to the input circuit and monitors the input level. Input signal should read in the green calibration on the meter.

q. Fuses. Eight fuse holders are the only items on the front panel of the power supply. The lower row of four holds spare fuses. The fuses are marked as follows:

(1) F1100 - The main power line fuse for the unit.

(2) F1101 - Fuses the fan, chopper drive, and ovens.

(3) F1102 - Fuses the primary of the filament supply transformer.

(4) F1103 - Fuses the primary of the plate

The power supply is designed for operation on 115 or 230 volts, 50-60 cycle AC. If connections are changed from one voltage to the other (see Operating Instructions 2.1c), the fuse sizes must be changed as follows:

FUSE	115V	230V
F1100	12 amp	6 amp
F1101	1 amp	1 amp
F1102	4 amp	2 amp
F1103	**3.2 amp**	**1.6 amp**

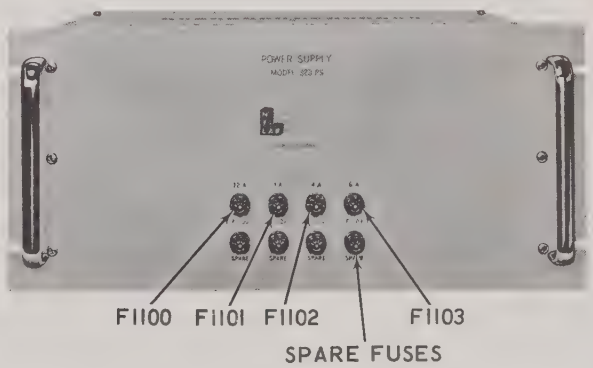


Figure 4. Power Supply - Front Panel

2.3 Applications

a. General. The primary function of the Model 323A is to act as a secondary standard to be used in the calibration of AC voltmeters. Because of its inherent characteristics as an accurately calibrated exceptionally stable source of AC voltage, and because of its wide frequency range and high output power capacity, the Model 323A is usable in a wide

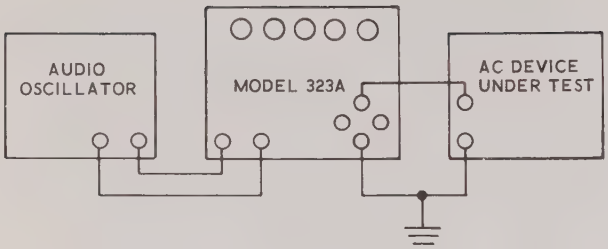


Figure 5. Voltage Calibration

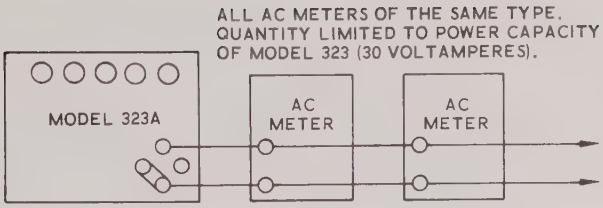


Figure 6. Production Voltage Calibration

range of calibration procedures. A few of the more common applications are detailed below.

NOTE

In the application diagrams that follow, the location of the ground connection is shown schematically in some appropriate location. Actual location of the ground connection must be chosen with extreme care in each calibration system. Ground loops may introduce errors in calibration. Holt engineers will furnish an approved grounding circuit for each application upon request.

b. Voltage Calibration.

(1) The wide range of output voltages permits the use of the Model 323A in the calibration of virtually every commercially available AC voltmeter. See figure 5. Since the voltage is variable and infinitely resolute, any and all full scale values may be checked as well as the linearity over any range. The wide frequency spectrum available offers the possibility of calibrating for a specific frequency or checking over a broad frequency range.

(2) Many companies have large quantities of meters that require accuracy checks at periodic intervals. The power capabilities of the Model 323A allow production testing of large numbers of instruments. This is accomplished by connecting all the meters in parallel across the output terminals. See figure 6. The best procedure is to set the Model 323A to a cardinal point voltage plus the tolerance; check all the meters to see how they read above the cardinal point; reject all those reading below. Reset the Model 323A to the cardinal point minus the tolerance; check all the meters to see they read below the cardinal point; reject all those reading above. Thus, the operator can select the instruments requiring calibration without the need to make any quantitative readings of the meters.

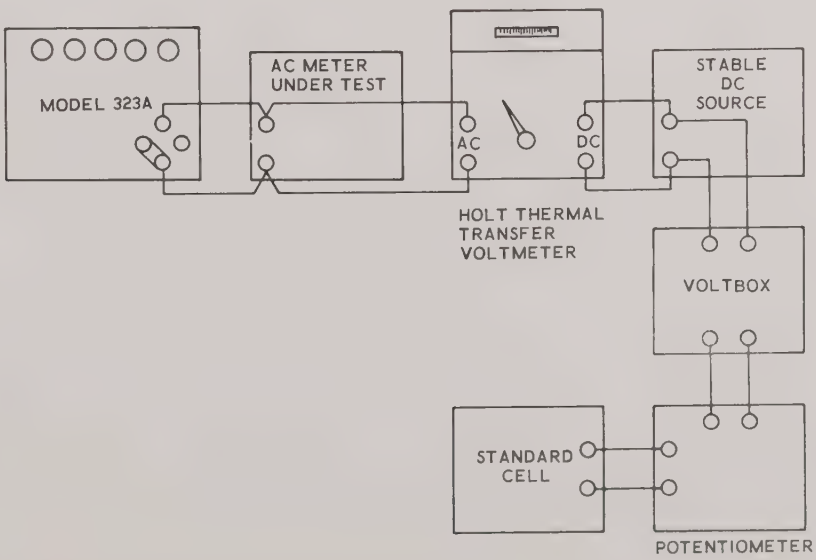


Figure 7. Typical Test Set-up for Transfer Standard

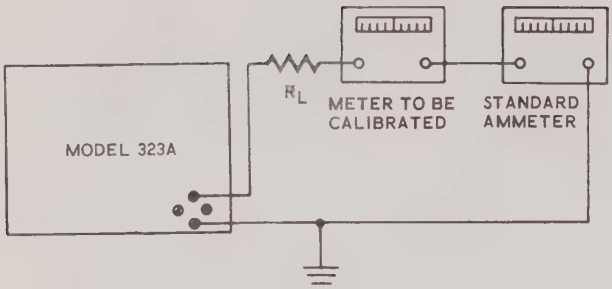


Figure 8. Ammeter Calibration

(3) Accuracies of calibration approaching those of DC measurements are possible by the use of a transfer standard, such as the HOLT TV1, used in conjunction with the Model 323A. Figure 7 illustrates a block diagram of the test setup using the Model 323A with a transfer standard. The Holt Thermal Transfer Voltmeter is essentially a device for comparing DC to an equivalent RMS value of AC. Its AC terminals are connected to the AC meter under test which is supplied from the Model 323A. (In this arrangement the stable output and infinite resolution of the output voltage of the 323A are very important.) Its DC terminals are connected to a stable DC supply. The accurate calibration of the DC supply is secured by comparison with the output of a standard cell through a potentiometer and a voltbox. By using the transfer standard to balance the AC calibrating voltage against the very accurately calibrated DC voltage, the meter under test can be calibrated to accuracies of .02% over the frequency range of the Model 323A.

c. Ammeter Calibration.

(1) The Model 323A may be used as a stable source of alternating current for the calibration of AC ammeters. The ammeter under test and a standard ammeter should be connected in series with a suitable current limiting resistor across the output terminals of the Model 323A. See figure 8. If the limiting resistor R_L is properly chosen with respect to the resistance of the standard meter R_S and the meter under test R_X, the output dials of the Model 323A will read directly in amperes or milliamperes with a reasonable degree of accuracy. Choose the value of R_L as follows:

Full scale current of meter	
3 amps	R_L equals $1 - (R_S+R_X)$
1 amp	R_L equals $10 - (R_S+R_X)$
100 ma.	R_L equals $100 - (R_S+R_X)$
10 ma.	R_L equals $1000 - (R_S+R_X)$
1 ma.	R_L equals $10K - (R_S+R_X)$

NOTE

If the meter to be calibrated is a passive meter (i.e. not connected to the power line) use the circuit illustrated in figure 8. If the meter to be calibrated is connected to the power line, the ground point must be carefully chosen to eliminate current leakage paths. One way to check for leakage currents is to insert a fixed resistor in the ground lead and measure the voltage drop across it.

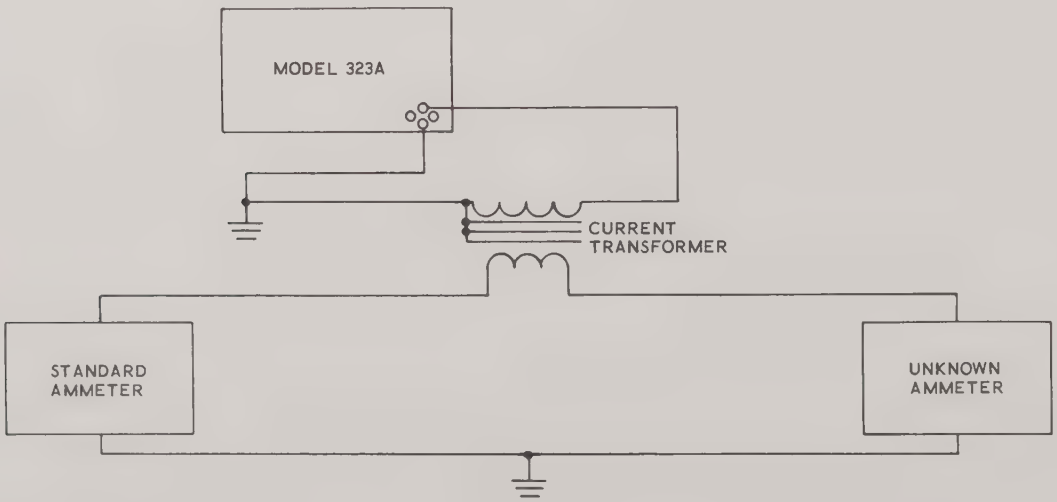


Figure 9. Use of Current Transformer

(2) An isolating current transformer connected across the output of the Model 323A will permit both ammeters to be grounded and also permit the calibrating current to be stepped up in proportion to the current transformer ratio. See figure 9 for the recommended circuit. Load must not exceed the rated 30 voltamperes. Holt Instrument Laboratories can recommend a transformer, or set of transformers, to fit the particular ranges of current, frequency, and burden required.

d. Wattmeter Calibration.

(1) The Model 323A has been provided with an auxiliary output terminal connected to the 1 volt tap on the output transformer capable of supplying up to 10 amperes. This terminal may be used as a source of current for the calibration of wattmeters. See figure 10 for the recommended connections. The resistor R is a carbon pile or wire wound rheostat used to set the current coils of the wattmeters. (It is sometimes desirable to make R from a 100 ohm rheostat in parallel with a 2 or 3 ohm rheostat to obtain better resolution.) At low frequencies (below 400 cycles), the standard wattmeter may be replaced by a standard ammeter and a standard voltmeter. Calibration by this method will be at essentially unity power factor.

NOTE

To check the phase angle, connect an oscilloscope with vertical deflection to point A and horizontal deflection to point B.

(2) Wattmeters and watthourmeters with current coils rated up to 10 amperes may be checked by the above method. Care must be taken to see that the total power drain does not exceed 30 watts.

e. Frequency Response Measurements. The ability to rapidly select a wide range of calibrated voltages at five different frequencies (or at any frequency if an external oscillator is used) make the Model 323A useful for checking the frequency response of amplifiers. Because of the high output power capability of the unit and the fact that the Model 323A is virtually insensitive to reactive loads, it is highly useful in checking the frequency response of filters and transformers.

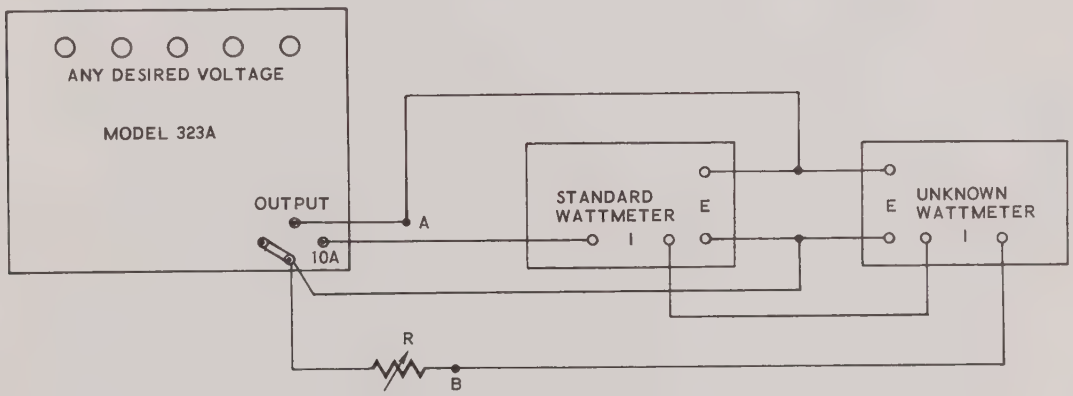


Figure 10. Wattmeter Calibration

SECTION 3
THEORY OF OPERATION

3.1 General Theory

a. The Model 323A is made up of two chassis units. The first, Power Supply Model 323 PS, contains all of the power supplies, regulators, and the reference pack. The second chassis houses the amplifier, input regulator, voltage selectors, and precision output transformers. Separation of the chassis provides a maximum of isolation of the 60 cycle power circuits from the low level signal circuits.

b. Power Supply Chassis.

(1) General. The power supply chassis can be divided into three basic circuits. Basic operation of these circuits is discussed below. Refer to block diagram of the power supply chassis (fig. 11).

(2) Reference Pack. Operating from a 115 volt AC source, the reference transformer powers two low voltage circuits. The first is a full wave rectifier that supplies power to operate the oven. This thermostatically controlled heater maintains

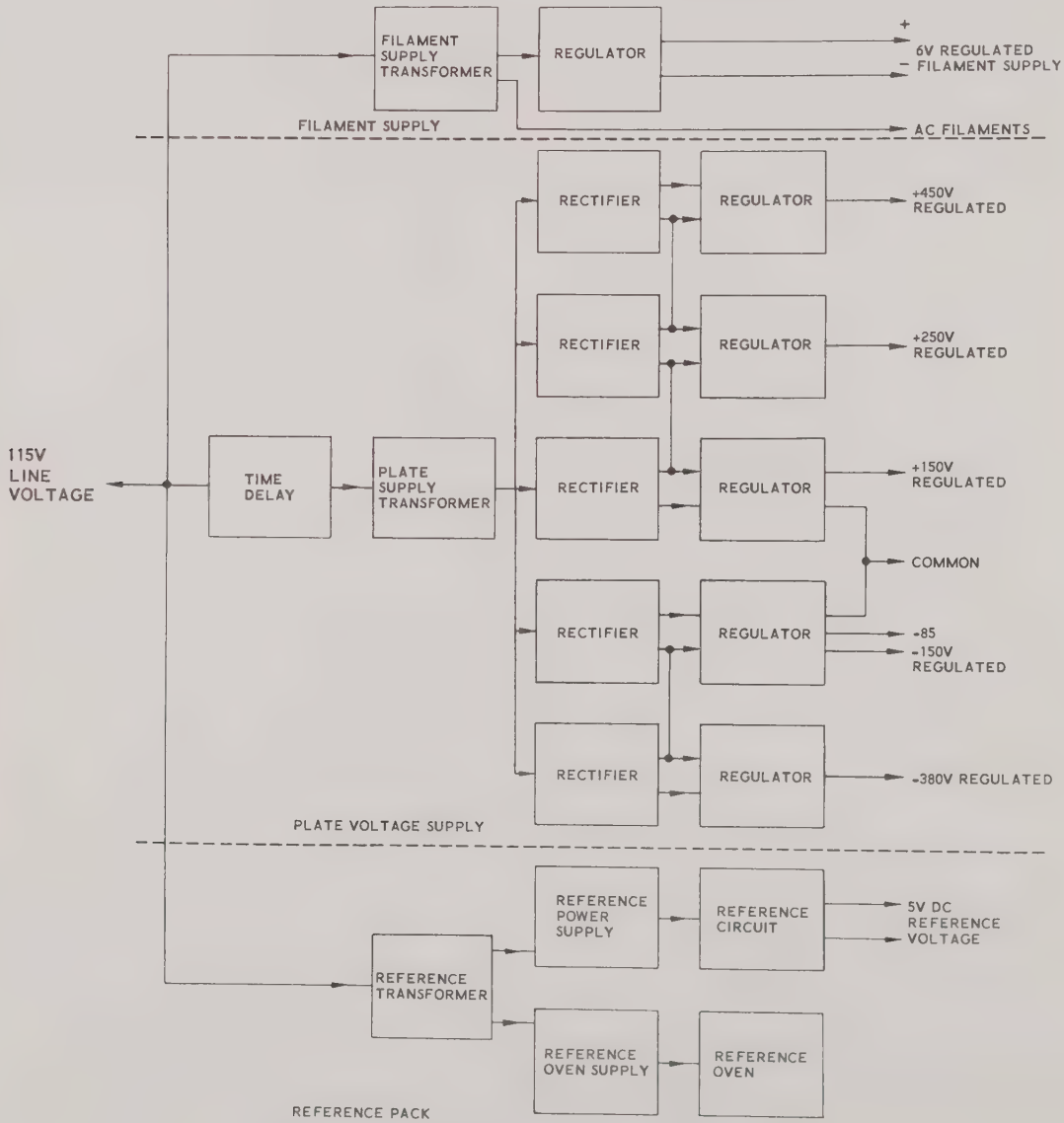


Figure 11. Power Supply - Block Diagram

the reference zener diode at a constant temperature to insure stable output. The second circuit is a full wave rectifier with solid state regulator which supplies voltage across the reference pack bridge circuit. Output from the bridge is a very stable 5.05 volts DC used as the reference voltage throughout the unit. Heart of the reference pack is the temperature controlled zener diode which is hand picked and aged to insure its stability within close limits.

(3) Plate Voltage Supply. The plate supply transformer is connected to its supply voltage through a thirty second time delay relay. This allows the heaters to warm up before plate voltage is supplied. The plate transformer supplies power to five rectifier and regulator circuits. Two of these supplies are connected in series and supply voltages below common. The three remaining circuits are connected in series to supply a number of positive voltages.

(4) Filament Supply. The filament transformer powers five AC filament circuits. In addition, it supplies a rectifier and regulator, all solid state, which provide a regulated DC filament voltage for the critical amplifier tubes of the unit.

c. Regulator Chassis.

(1) General. The theory of operation of the audio voltage standard can best be described by referring to the block diagram, figure 12. The regulator circuit is made up of a power amplifier and a control loop. Any error in the output of the power amplifier is detected by an error circuit and corrected by the input regulator circuit. Each of these three circuits are discussed below.

(2) Power Amplifier. The input selector switch connects the amplifier input to an external oscillator or to the internal oscillator. The internal oscillator allows a choice of five pre-selected frequencies. The input signal is applied across the 600 ohm input impedance of the input regulator. The signal fed from the input regulator is controlled by a DC correction signal from the control amplifier. From the input regulator, the input signal is applied to an input attenuator and then to the power amplifier. A push button switch enables the operator to monitor input level or output voltamperes on a front panel meter. The power amplifier output is delivered to a set of tapped output transformers. The output selector switches select the proper tap

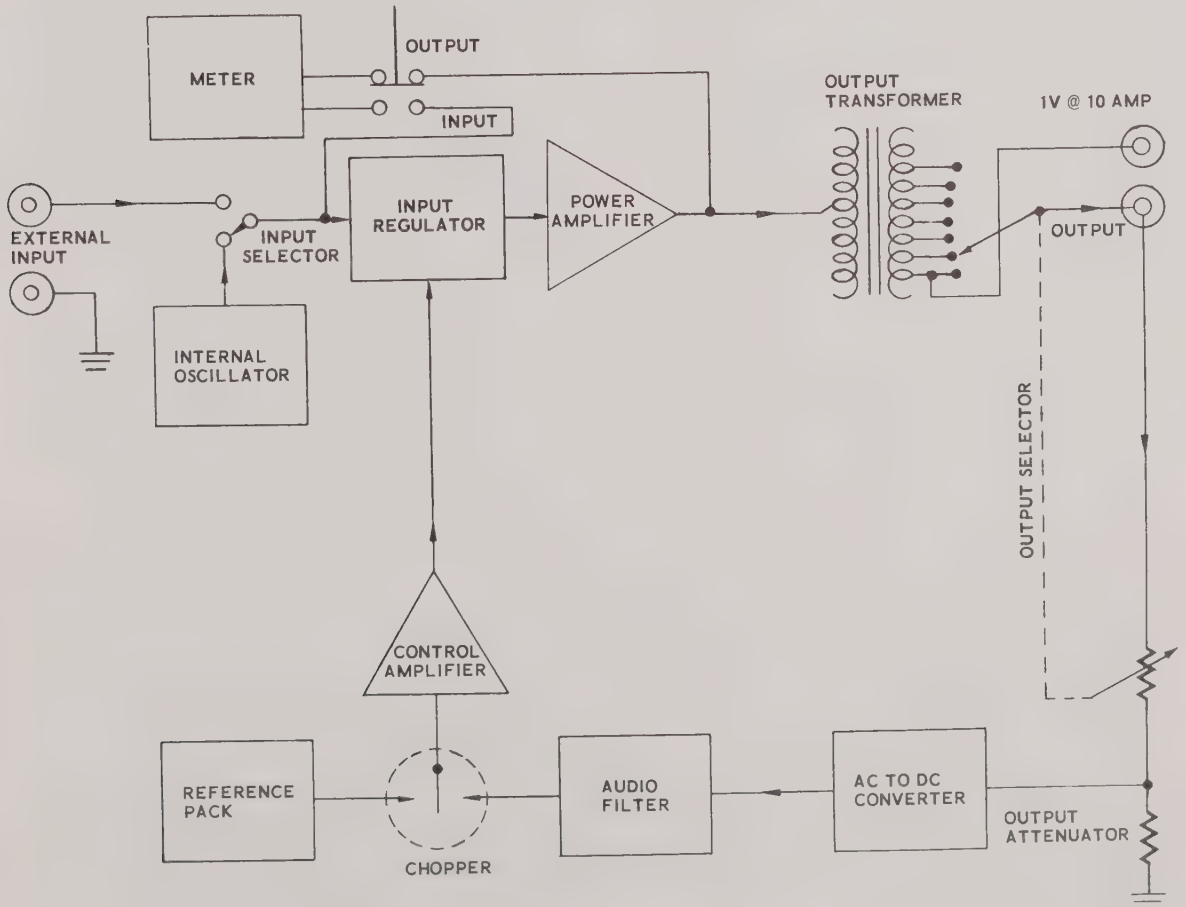


Figure 12. Regulator - Block Diagram

to deliver the required voltage output and also select the proper voltage divider resistor to give an output voltage of one volt at the input to the AC to DC converter.

(3) Error Circuit. The voltage is connected across the output terminals and its resistor values are selected to give one volt of input to the AC to DC converter when the output voltage is correct. The variations of voltage at the input to the converter stage will always be proportional to the variations in the output voltage. The function of the error circuit and the control amplifier is to keep the voltage at the divider tap equal to one volt, and thus set the output voltage to the correct value. The AC to DC converter is an averaging device whose DC output is proportional to its AC input. This DC output is then filtered by an M derived low pass audio filter and applied to one contact of a 60 cycle chopper. If the output voltage as set by the selector switch is correct, the DC level to the chopper will be five volts. The chopper compares this five volt output signal with a very exact voltage reference signal from the reference pack. Any difference between the two signals must be due to an incorrect output voltage and results in an error signal from the chopper circuit. This error signal is a very low level, 60 cycle signal which is fed to the control amplifier.

(4) Control Amplifier and Input Regulator. The error signal fed to the control amplifier is a 60 cycle voltage whose level is proportional to the error in the output voltage. It is essentially a square wave. The control amplifier raises the level of this signal, feeds it to a phase inverter and then to a synchronous demodulator (part of the chopper). The DC output of the demodulator is filtered by an RC combination whose time constant is controlled by the recovery module during overload. The resulting DC varies in amplitude and polarity in proportion to the error in the output voltage. This DC signal is amplified by a DC amplifier and used to control the input regulator. The input regulator, in turn, will vary the input audio signal level in such a manner as to reduce the error signal to zero.

3.2 Basic Circuit Theory

The paragraphs that follow will each be devoted to a discussion of the operating theory of one of the basic circuits that make up the Model 323A. Each circuit discussion will cover one schematic diagram so far as possible, although the interconnection of the circuits will require reference to more than one schematic in some cases. All schematics will be found at the end of the text. Reference will be made by schematic title, rather than by figure number. Refer to the block diagrams (figs. 11 and 12) to better understand the position of each circuit in the action of the Model 323A.

3.3 Internal Oscillator

a. The basic circuitry of the internal oscillator is shown in block diagram form in figure 13. Oscillation is accomplished by feeding back the output signal from the main amplifier through a "bridge tee" RC circuit. This RC circuit determines the frequency of oscillation. Some output signal is also applied across a thermistor bridge. The DC output of the thermistor bridge is amplified by the AGC amplifier and fed back to the main amplifier to stabilize the output level. Negative feedback is employed across both amplifiers to stabilize their operation.

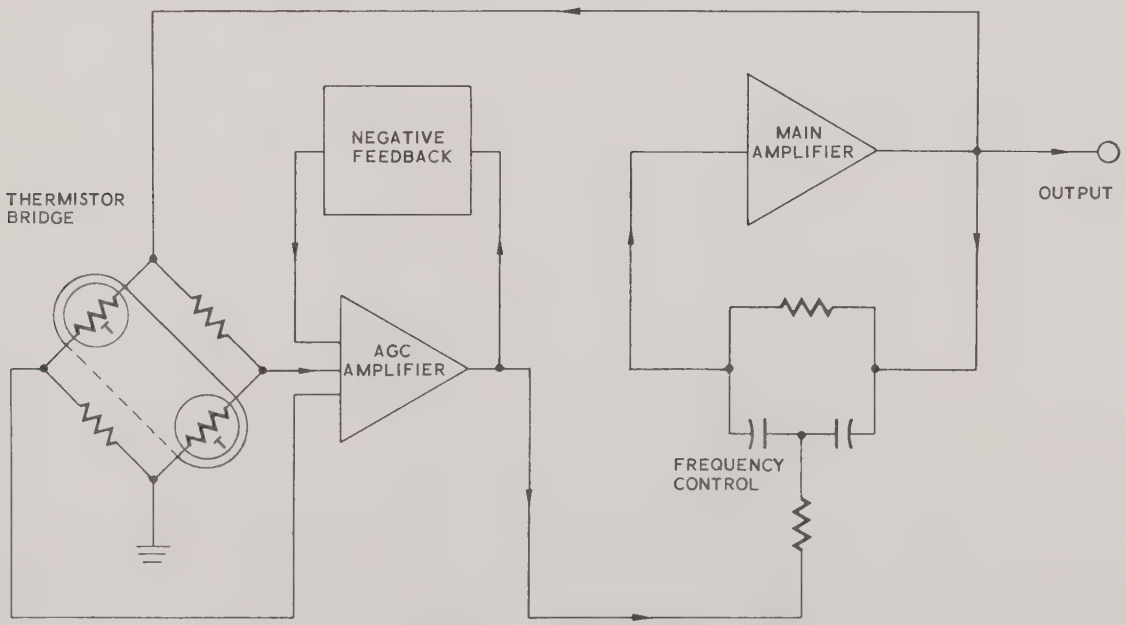


Figure 13. Internal Oscillator - Block Diagram

b. Refer to the schematic INTERNAL OSCILLATOR. The main amplifier consists of V202, V203, and V204 connected as a four stage direct coupled amplifier. The AGC amplifier consists of V200 and V201 also direct coupled. Both amplifiers employ negative feedback to stabilize their operation. Oscillation is secured by feeding back an output signal from the cathode of V204 through the AGC amplifier to V202. This signal is regenerative and of sufficient amplitude to cause oscillation at the fundamental frequency determined by the band pass characteristics of the bridge tee.

c. The output frequency is controlled by two switches, the input selector switch and the internal frequency vernier. The input selector switch, S200, selects the proper values of the bridge tee for operation at the five desired frequencies. The internal frequency vernier, S201, switches a small value of capacity across the capacitors in the bridge tee. The value of capacity in each position is sufficient to change the frequency by increments of two percent. High precision, stable components are used in the bridge tee to insure accurate and stable frequency control.

d. The thermistor bridge controls the amplitude of the output signal. Output from the cathode of V204 is applied across the thermistor bridge. The inputs to the AGC amplifier are taken from the bridge, each side of the bridge supplying one grid of V200. When the amplitude of the output voltage rises, the thermistors heat. This decreases the proportional amount of regenerative feedback supplied by the AGC amplifier, and the net result is a decrease in output. This combination functions to keep the output at a constant level of ten volts at the cathode of V204.

e. The thermistor bridge is temperature sensitive and requires an oven for stable operation. The oven temperature is maintained at 55 degrees C. (± 1 degree) by a thermostat and transistor control circuit. Transistors Q200 and Q201 act as a switch controlled by the thermostat and operate the oven heater. The oven, switch circuit, and heaters of all tubes in the oscillator are operated from the six volt regulated DC supply, thereby minimizing the 60 cycle component in the oscillator output.

3.4 Power Amplifier

a. The power amplifier consists of four sections: a high gain pre-amplifier, a phase inverter, a driver amplifier, and the power output stage. See figure 14.

b. The pre-amplifier consists of V501A and V501B and V502A. These tubes make up a frequency compensated, three stage, single-ended amplifier. This amplifier is designed for high gain and low noise. Feedback of approximately 20 db. is fed from the cathode of V502A to the cathode of V501A.

c. The phase inverter (V502B) is a single stage, split load type circuit. It is inherently a self-balancing circuit, although a balance control (R514) is provided in the plate circuit to insure balance of the output signals and minimize even order harmonics.

d. The driver amplifier consists of three stages (V503, V504, and V505) in push-pull. Each stage is frequency compensated and capable of amplifying very large signals. Additional signal swing is made possible by feeding the plates of V504 and V505 from the output screens, thus introducing a small amount of regenerative feedback.

e. The final amplifier consists of V506 and V507, a pair of 6550 tubes in push-pull. The final amplifier is assembled on a metal chassis for improved heat dissipation. The final tubes are split loaded and operated as class AB1 amplifiers. This combination provides the best possible power output at the lowest possible distortion. Connected with the cathode windings of the output transformer (T100)

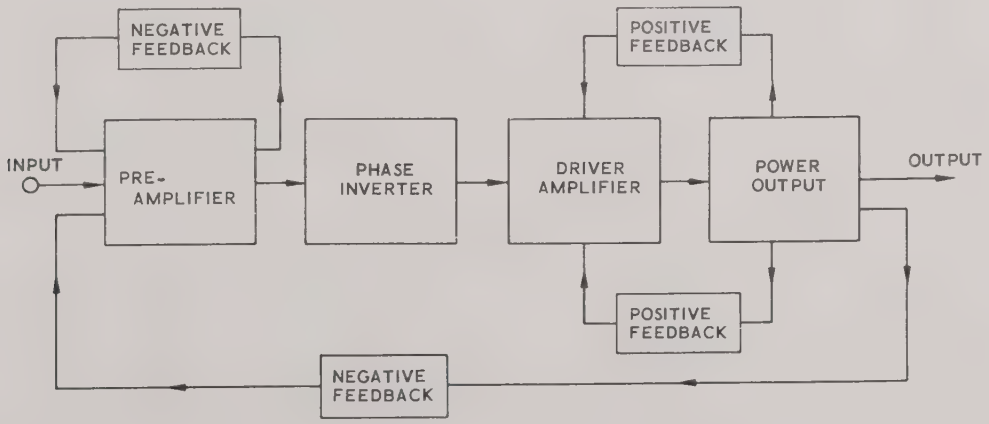


Figure 14. Power Amplifier - Block Diagram

is the primary of a small current sensing transformer (T101). The secondary of this transformer provides an output signal proportional to the final amplifier signal current. This signal is used to monitor the output voltamperes. See the description of the meter circuit (par. 3.10) for further information. Taps 1 and 2 on the output transformer provide additional feedback around the complete amplifier. Feedback is returned to the cathode of the input pre-amplifier.

3.5 Voltage Switching and Attenuator Circuit

The voltage output switching and the attenuator system used to sense the output voltage to establish correct values are, in a sense, the heart of the Model 323A. Use of high quality, stable, factory selected components is essential if high precision output calibration is to be maintained. The schematic diagram VOLTAGE SWITCHING AND ATTENUATOR can be divided into five sections as described below.

a. Output Voltage Selection (1 to 1000 volts). Voltage selection in the Model 323A is accomplished by switching to the proper output transformer secondary tap. Two secondaries are provided on the output transformer (T100). They are connected so their outputs are additive. The secondaries are tapped to provide 1 and 10 volt output steps respectively. By selecting the proper voltage taps, increments of 1 are available from 1 volt to 99 volts. Note that no tap is provided for less than one volt. For voltages above 99 volts, the 90 volt output transformer winding drives either of two secondary step-up transformers (T102 and T600). These step-up transformers have a secondary tapped in 100 volt increments from 100 volts up to and including 900 volts. For the best possible frequency characteristics, two high voltage transformers are employed. The first (T102) is used at frequencies below 1 kilocycle and the second (T600) above 1 kilocycle. Switching these transformers is necessary only above 99 volts and is accomplished by the Input Selector Switch. Switching is accomplished automatically (through relay K600) when selecting an internal frequency. When changing to a frequency above 1 kc. from an external source, the switch must be properly positioned. The output of the high voltage transformers is additive with that of the normal output transformer.

b. Output Voltage Selection (below 1 volt). When the range selector (S103) is positioned anywhere below the 1 to 1000 volt range, the level in the output transformer does not change. Instead, a precision ratio transformer (T601) is driven from the 1 to 10 volt taps. Two ratios are available: 10:1 and 100:1. Choice of ratios is determined by the Range Selector Switch.

NOTE

The 10 and 100 volt switches are not used when operating below 1 volt. These dials are disconnected electrically and by mechanical linkage, zero's appear in the indicator windows.

c. Output Attenuator. The output attenuator is a precision resistive divider which is changed in value by the voltage selector switches (S600 through S604). Resistances are selected in such a manner that a constant 1 volt level is maintained at the input to the AC to DC converter AS LONG AS THE OUTPUT IS CORRECT. Variations in output terminal voltage are reflected as variations in the 1 volt level and appear at the input to the converter. The primary requisite of the output attenuator circuit is that it be precise in ratio and long term stability. Inspection of the attenuator and voltage selector circuits will disclose additional switch contacts required to provide the logic switching over the entire voltage range of the unit.

d. Input Attenuator. When operating in the .1 volt (S603A) positions at less than 10 volt output, an input attenuator is used ahead of the power amplifier. This divides the voltage input to the power amplifier to compensate for a change in output transformer taps to reduce the voltage variation required by the control amplifier-input regulator combination. The input attenuator is disconnected from the circuit when the .1 volt (S603A) dial is on zero, and when the 100 volt (S600B) and 10 volt (S601B) dials are not on zero.

e. Frequency Compensation. In order to insure that the output is flat across the entire operating frequency range, the output attenuator is compensated during the factory calibration procedure. Since compensation will differ slightly from one model to the next, the values of capacity shown on the schematic are nominal values.

CAUTION

Each Model 323A is individually compensated at the factory for the distributed capacity of its own wiring and components. DO NOT CHANGE THE POSITION OF THE WIRING OR OF THE COMPONENTS IN THIS SECTION. Any movement of parts or wiring will necessitate recompensation of the output attenuator.

3.6 AC to DC Converter

a. The input to the converter stage appears across a network of resistors R700, R701, and R704. This combination actually makes up the lower resistor of the output attenuator circuit. See figure 15. Resistor R704 is adjustable and is used to calibrate the output attentuator. High frequency compensation for the converter is supplied by the variable capacitor (C709). The nominal one volt input to the converter appears across the resistance network.

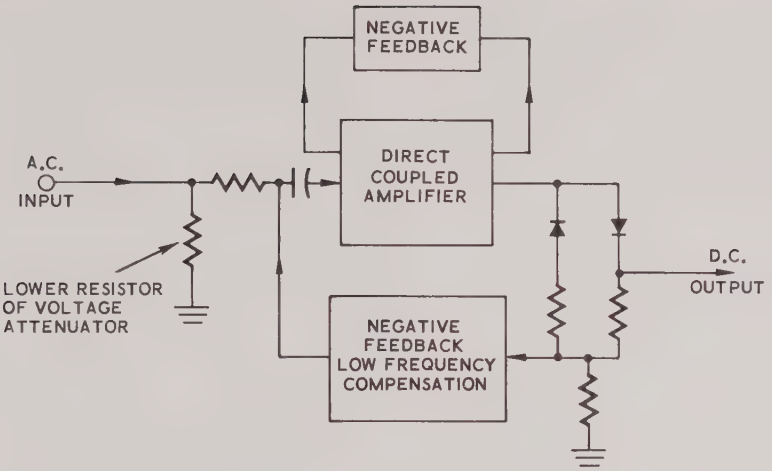


Figure 15. AC/DC Converter - Block Diagram

b. The direct coupled amplifier consisting of V701, V702, and V703 is frequency compensated and employs DC feedback to stabilize its operation. The output of the amplifier drives a cathode follower V704. DC feedback is taken from the output of the cathode follower and applied to the amplifier input grid. The DC output from the converter is taken from the cathode follower through diode (CR701). An AC feedback loop is also fed from the same cathode follower through diodes (CR701 and (CR700). This AC feedback is returned to the converter input through an RC network chosen to supply low frequency compensation. Resistor (R721) is the low frequency compensation control.

c. The output of the converter stage is a positive half wave of voltage taken across R729 and R728. Since this voltage is the result of amplifying and rectifying the one volt signal from the attenuator, the resulting DC voltage is proportional to the output voltage at the terminals of the Model 323 A

3.7 Control Amplifier

The schematic diagram titled CONTROL AMPLIFIER includes the diagrams of the audio filter and chopper circuits as well as the control amplifier itself. See figure 16 for a block diagram of the control amplifier and chopper circuit.

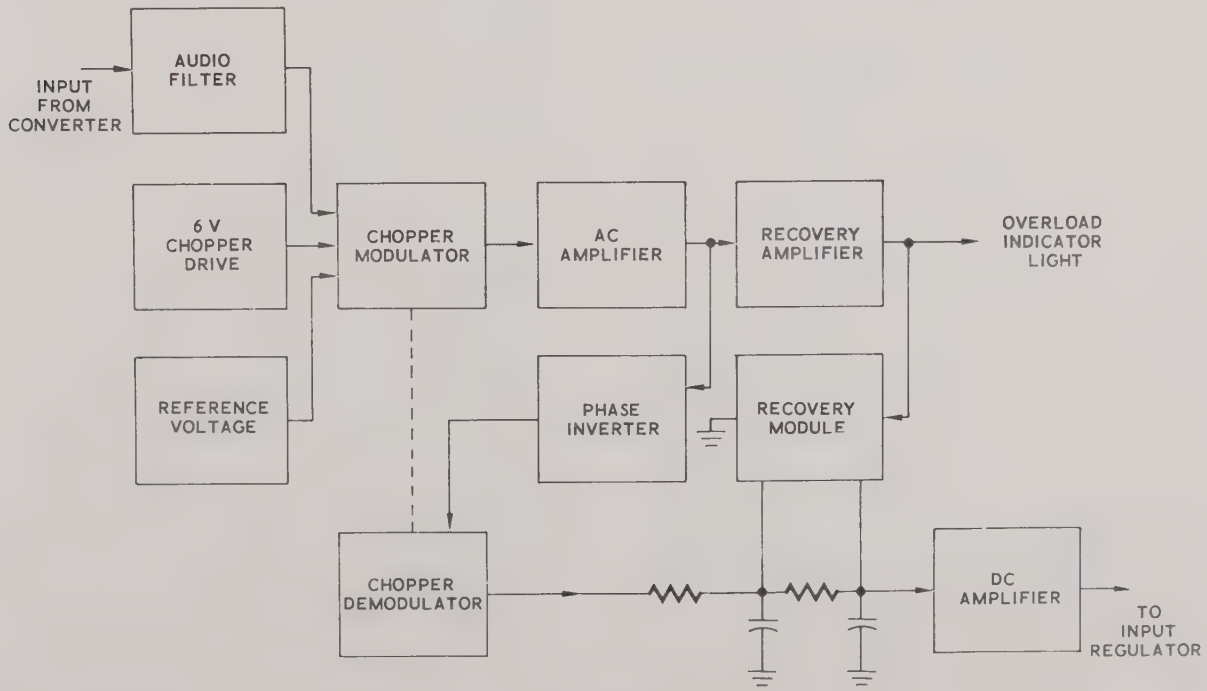


Figure 16. Control Amplifier - Block Diagram

a. Audio Filter. The rectified positive half waves of voltage from the AC to DC converter are fed to the audio filter. This M derived low pass filter has a cutoff value of about 20 cycles and falls off sharply above 20 cycles. Response through the filter is from DC to approximately 20 cycles per second. The output from the filter is a nominal 5 volts positive DC voltage and is applied to pin 1 of the chopper.

b. Chopper Circuit. The chopper is a two pole device. One pole, a make-before-break switch, is used as a modulator; the other pole, a break-before-make switch, is used as a synchronous demodulator. The chopper is a 60 cycle device driven from the 115 volt AC supply through L1101. The function of the modulator section is to compare the output of the audio filter with the positive five volt DC reference voltage. Since both are five volt positive levels, there will be no output from the chopper modulator unless one level varies. The reference level is fixed so error signal will appear only when the output of the audio filter changes and this level is proportional to the output voltage at the terminals. The 60 cycle signal from the modulator will, therefore, serve as an indication of the error in the output terminal voltage. The amplitude of the error signal will indicate the amount of error and the phase will indicate the error above or below the calibrated output voltage.

The second section of the chopper, the demodulator, is connected following the phase inverter in the control amplifier. Its function is to convert the amplified square wave error signal to a DC signal that varies in amplitude and polarity in proportion to the amplitude and phase of the error signal.

c. Control Amplifier. The control amplifier consists of three basic sections; an AC amplifier and phase inverter, the recovery amplifier and recovery module, and a DC amplifier.

(1) AC Amplifier. The low level 60 cycle error signal from the chopper modulator is fed to the input grid of the AC amplifier. This amplifier consists of a four-stage amplifier (V401, V402A and B, V404A) followed by the phase inverter (V404B). The first three stages provide about 75 db gain. A feedback loop through C419 provides 10 db feedback to improve stability across these three stages. Three diodes (CR401, 2, 3) located in the grid circuits have no effect on low level signals, but provide an easy path for discharging the coupling condensers in the event of large signals thus preventing blocking of the amplifiers. Resistor R430 is an adjustable control for servicing purposes. In normal operation it remains in the maximum signal position. It can be turned down to allow testing of the AC amplifier without the correction loop functioning. V404A provides an additional 20 db gain into the phase inverter. The output of the phase inverter is applied to the chopper demodulator. This output is a square wave which, under maximum error conditions, will not exceed 50 volts peak-to-peak.

(2) Recovery Amplifier. An error signal from the plate of V402B is fed into the grid of V403A, the input of the recovery amplifier. This input signal is a square wave that may approach 25 volts peak-to-peak under maximum error conditions. Output is taken from the cathode of V403A and rectified by diode CR404. The resulting DC voltage is coupled to transistors Q401 and Q402 which act as a DC amplifier. Capacitor C418 is employed in a circuit with a relatively long time constant, thus preventing rapid changes in the input level to the DC amplifier. Collector current from Q402 flows through the recovery module between terminals 2 and 4. This variation in current flow results in a change in resistance between terminals 1 and 3 on the module. The resistance will vary between 1000 ohms and infinity as the current flow varies from maximum to zero. The output of this transistor amplifier is also used to control the overload indicating light through an additional two stage solid state amplifier. (See Meter Schematic.) With maximum error signal, the voltage at the collector of Q402 will be approximately five volts and the lamp will light. When the error is reduced to zero, the collector voltage will drop to zero and the lamp will go out.

(3) DC Amplifier. The output of the chopper demodulator is a DC voltage which varies in proportion to the error signal. This DC voltage is filtered by an RC network containing C423 and C424. These two capacitors and their associated resistors have a long time constant which would limit the response of the control circuit to rapid variations in error signal. In order to provide a variable time constant in this filter, the recovery module is bridged across R443. Since the resistance of the recovery module varies with error voltage (through the recovery amplifier), the time constant of the filter can also be varied in proportion to the error signal. The resulting DC control voltage is applied to the grid of V403B, a cathode follower, and then to Q403, an emitter follower. The DC voltage at pin 13 of P400 is approximately + 2.5 volts with no error signal applied. This output voltage from the emitter of Q403 is used to control the action of the input regulator and thus control the output voltage. Resistor R448, in the emitter circuit, is adjusted with 1 volt input at J102 and J103. Set R448 to provide 0 voltage on the grid of V403B.

3.8 Input Regulator

The input regulator is a sealed unit operated from a + 150 volt supply. Its function in the circuit is to control the input signal voltage in such a manner as to keep the error voltage at zero. The DC control voltage from the DC amplifier is supplied to terminal 1. The output voltage from terminal 5 will vary in level as controlled by this DC voltage.

3.9 Reference Supply

The REFERENCE SUPPLY schematic contains diagrams of the four circuits required to supply the five volt reference voltage to the chopper. This

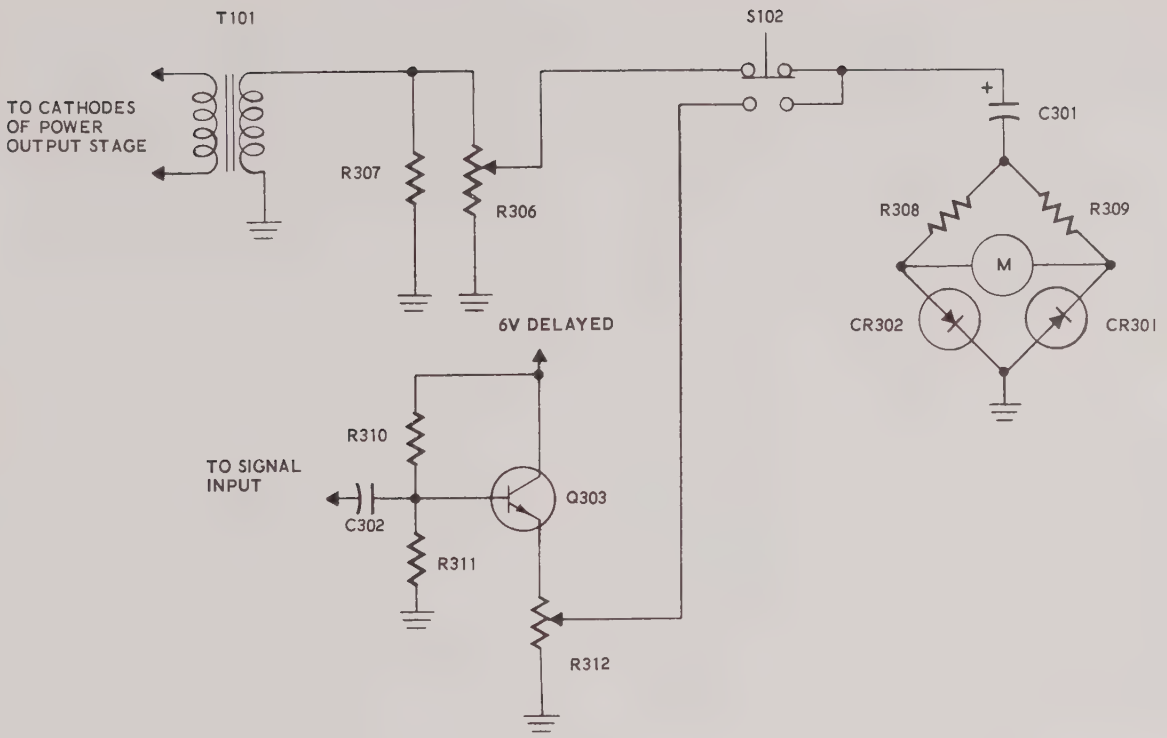


Figure 17. Meter Circuit

reference supply is a plug-in module and is completely self-contained. See figure 11 for a block diagram of the reference pack. It houses its own power supply for the oven; the oven heater and its controls; the precision zener reference and bridge; and the power supply and regulator for the bridge.

a. The reference supply power transformer furnishes power to four diodes (CR1005) through CR1008) arranged in a full wave bridge circuit. This rectifier circuit supplies operating voltage for the oven, oven control, and oven indicator light.

b. The reference zener diode assembly (Z1000) contains the oven heater and thermostat control switch. Switching of the heater is done by a transistor (Q1001) which is controlled by the thermostat. Use of the transistor switch eliminates the transient voltage spikes otherwise present. The oven is designed to maintain the reference diode at 60° C (± 0.1 degree). The indicator light cycles on and off with the oven heater and indicates proper operation of the reference oven.

c. The supply voltage for the reference bridge is furnished by an isolated secondary of transformer (T1000). The rectifier is a full wave supply employing diodes (CR1000 and CR1001). Conventional RC filtering supplies DC to the transistor current regulator. All of the current to the bridge circuit passes through R1003 and transistor (Q1000). The zener diode (CR1002) fixes the combination of the voltage drop across the resistor (R1003) and the base-emitter voltage of the transistor (Q1000) at a constant voltage. Thus the emitter-base current and, therefore, the emitter-collector current of the transistor is held constant. The zener diode (CR1003) regulates the voltage to the bridge current.

d. The zener bridge circuit is the source of the reference voltage and its stability determines the accuracy of calibration of the Model 323A. The zener reference diode is carefully selected and aged over a ninety day period to insure its long term stability. The bridge circuit is carefully balanced with a current of approximately 1 milliampere flowing in the center arm. Resistor (R1009) is adjusted to provide the reference voltage which, at this point, is 5.05 volts ± .005% into a 10.2 K ohm load. The bridge is balanced for minimum noise by adjusting resistor (R1011). Calibration of the reference supply is a precise and exacting task and recalibration without precise standards or by personnel without past experience on this type of equipment is discouraged.

3.10 Meter

The METER schematic diagram illustrates the major portion of the circuits of two indicating devices, the front panel meter and the overload indicator light. See figure 17 for simplified diagram of the meter circuit.

a. The meter is connected across a rectifier bridge since the input and output to be measured

are AC signals. With the switch (S102) INPUT LEVEL CHECK BUTTON in the UP position, the meter is connected to the arm of a load calibration potentiometer (R306). This control is connected across the secondary of transformer (T101). This is the transformer whose primary is in the cathode circuit of the power output tubes. The voltage from this transformer is proportional to the output current. Since the voltage across the output transformer primary is essentially constant, the meter can be calibrated in output voltamperes. The calibration potentiometer (R306) is adjusted to provide a 30 VA reading at 1 kc with an output voltage of 10 volts and a resistive load of 3.3 ohms.

With the button depressed (switch in the lower position), the meter is connected to the output of a transistor isolation amplifier. This emitter follower (Q303) isolates the meter circuit from the input to prevent loading of the input circuit. An adjustable resistor (R312) in the emitter circuit serves as a calibration adjustment. It is adjusted by applying 1 volt at 1 kc to the input terminals and adjusting R312 (with button depressed) until the meter needle reads at the lower edge of the green scale section. The input to the isolation amplifier is taken from the input circuit just ahead of the input regulator and thus the meter reads input regardless of whether an internal or external oscillator is used.

b. The regulator overload light circuit is controlled from the error signal. The error signal from pin 1 of Plug (P300) is a DC voltage that is applied across a voltage divider to the base of transistor (Q301). This transistor and the one following (Q302) make up a DC amplifier. This amplifier is powered from the six volt DC source and collector current from Q302 operates the overload lamp when error voltage is sufficiently high.

3.11 Filament Supply

a. Filament supply transformer (T1101) supplies power to six secondary windings. Five of these windings supply the heater requirements for the AC heated power supply regulator tubes and other tubes with normal heater requirements.

b. The sixth winding on the filament power transformer supplies power to a full wave rectifier. Output of the rectifier is filtered by an LC filter and applied to a series pass regulator. Transistors (Q1201 through Q1204) are connected in parallel in order to handle the total current from this supply. A half ohm resistor in each emitter insures an even division of current through the group. The amount of current passed by the group is set by transistor (Q1200) which controls the base voltage on the group. Since the current drain from this supply is high and the voltage drop in the leads is, therefore, large, the regulated voltage is sensed at the point of application. Pins 11 and 12 of Plug (P1200) carry the sensing voltage to the regulator where it is applied to transistor (Q1205). Transistors (Q1205 and Q1206) and their associated zener diodes control transistor (Q1200) which regulates the output at 6 volts. This regulated DC supplies the heater requirements for those tubes where AC pickup or a varying supply voltage would introduce problems. This regulated supply is also used to power the transistor circuits.

c. A thermal switch (S1200) is located on the heat sink to which all of the power supply transistors are attached. In the event the temperature of the heat sink exceeds safe operating limits, this switch will open Relay (K1100), disconnecting the AC power to the complete unit. The heat sink assembly is located directly in front of a ventilating fan to keep temperature levels within reasonable operating limits.

3.12 High Voltage Supply

a. The -85, -150, and -380 Volt Supplies. A voltage regulator tube (V1503) is used to set the -85 volt level. This stabilized voltage is then employed as a reference to control the -150 regulator circuit. The -150 volt supply is closely regulated and noise is kept to a minimum since the output of this regulator is the reference level controlling other power supply regulators. V1502 senses the output voltage and compares it to the -85 volts from the reference tube. The error is amplified by V1501 and used to control the series pass tube (V1500) thus regulating the output voltage. The -380 volt supply employs V1504 as a pass tube in a similar type regulator. Power supply regulators are designed to hold the output constant with a ± 10% variation in supply voltage.

b. The +150 and +250 Volt Supplies. These two circuits are similar in circuitry. Both employ half of V1402 in a series pass tube arrangement. Both use the -150 volt regulated output as a reference voltage. The output in each circuit is sensed by a 12AX7 and the error amplified by a 6KD6 and used to control the pass tube.

c. The +450 Volt Supply. This circuit is similar to the other regulator circuits described above. Both halves of V1300 are connected in parallel and used as the series pass tube. The output is sensed by V1302 and compared with the +150 volt reference. The error voltage is amplified by V1301 and used to control the pass tube.

d. All of the rectifier circuits are of the full wave bridge type except for the -380 volt circuit which is a half wave rectifier. Refer to the block diagram (fig. 7) for the position of each circuit in the overall power supply combination. Note on the schematic that all power supplies are series connected, as well as using various outputs as reference voltages in other regulator circuits.

3.13 Power Supply Interconnection

a. This schematic illustrates the interconnecting cables that power the Model 323A. Some of the items shown have been discussed in previous paragraphs. See paragraph 2.1 for power supply connections, paragraph 2.2q for fuses, and paragraph

3.11c for the switch controlling relay (K1100).

b. The thermal time delay relay (K1102) is activated when the power switch is turned on. After a thirty second delay to allow the tubes to heat, the time delay relay closes, closing relay (K1101) which in turn locks itself closed. Relay (K1101) disconnects the time delay relay and applies power to the plate supply transformer.

3.14 Regulator Interconnection

a. This schematic illustrates the wiring which connects the various modules that make up the regulator unit. Most circuits have been discussed in previous paragraphs in this section.

b. The operate relay (K100) is closed by placing the standby switch (S101) in the OPERATE position. The relay then connects the operate light and turns on the chopper drive.

SECTION 4
RECALIBRATION

4.1 Recommended Test Equipment

When recalibrating the Model 323A at periodic recalibration intervals, or after repairs have been made, the following test instruments should be used, or other instruments of similar quality:

Distortion Analyzer	Hewlett Packard Model 330B
Wave Analyzer	Hewlett Packard Model 302A
Audio Oscillator	Holt Model 448
AC Transfer Voltmeter	Holt Model TV1
DC Supply	Holt Model 325
DC Potentiometer	Leeds & Northrop Model K3
Standard Cell Bank	Eppley Saturated Cells

4.2 Procedure

(1) Method I. Using a wave analyzer connected to the output terminals and tuned to the second harmonic of the fundamental frequency, adjust the balance control (R514) for minimum second harmonic component. Measure and compute the total harmonic distortion.

(2) Method II. Using a total harmonic distortion analyzer connected to the output terminals, adjust the balance control (R514) for minimum distortion.

The total distortion should not exceed 0.030% on internal oscillator with no load.

b. Control Amplifier and Meter Calibration. With the Model 323A regulating at a frequency of 1 kc from an external oscillator, set the input voltage to one volt. Connect a vacuum tube voltmeter to the grid (Pin 2) of V403B and adjust R448 until the grid voltage measures zero. With the same operating conditions as above, the meter input calibration can be adjusted by depressing the INPUT LEVEL CHECK BUTTON and adjusting R312 until the meter needle reads at the lower edge of the green section of the scale. The output meter can be calibrated by dialing ten volts output (input conditions as above), connecting a 3.3 ohm resistive load to the output terminals and adjusting R306 so the meter reads 30 VA.

SEE ADDENDUM

c. Reference Voltage Calibration. Do not attempt to make this adjustment without precision DC standards equipment, or operation outside of the specifications may result. Place the Model 323A in "Standby" and remove the chopper (G401) from its socket. Allow one half hour of warmup to permit the reference element temperature to stabilize. The reference voltage may be measured at the control amplifier connector (P400) Pin 12 with respect to Pin 10. This voltage must be 5.0500 volts ± 0.005%.

NOTE

In order to make DC measurements to this accuracy, the unknown voltage is connected to oppose the voltage of standard cells which are connected in series. The difference of potential between the standard cells and the unknown voltage is measured with the DC potentiometer. This differential measurement technique permits minimum loading on the unknown voltage source. Do not attempt to make this measurement by using a volt box.

If adjustment is necessary, remove the reference pack top cover and note the access hole in the top of the insulation covering the oven assembly. If the hole is not provided, remove this piece of insulation and with a sharp tool make a small hole to correspond with the adjustment screw of R1009, the trim pot located closest to the connector on the resistor assembly board.

CAUTION

Do not confuse R1009 with the trim potentiometer (R1011) located nearby. R1011 is set at the factory and requires no further adjustment. Under NO conditions should R1011 be tampered with. R1011 is used to balance the bridge including the reference element, and it is peculiar to that particular reference element. Misadjustment will affect both the noise and the reference voltage level.

To adjust the reference pack output voltage, adjust R1009 to obtain 5.0500 volts ± 0.005% while monitoring the output. This voltage must be accurately adjusted because it will affect all output voltages of the Model 323A.

If the Model 323A is not located with access to standards equipment, the reference pack has been designed to be easily removed from the power supply and transported to the standards laboratory for periodic calibration. The reference pack is energized with 115 VAC applied to Pins 15-16 of P1000. It is necessary to provide a load impedance of 10.2 K ohms ± 0.01% across Pins 1-2 of P1000. This load impedance corresponds to the control amplifier circuitry. The reference pack output voltage is developed across this resistance.

d. One Volt Output Calibration. Do not attempt to make this adjustment without precision standards equipment, or operation outside of the specifications may result.

With the Model 323A operating at 1 kc and the output voltage set at one volt, after a one-half hour warmup, measure the output terminal voltage with a precision AC voltmeter. The voltage must be 1.000 ± 0.01%. ON THE 1-1000 VOLT RANGE

To adjust the output voltage, adjust R405 which is accessible through a hole in the rear plate. See figure 18 for location of access hole. Clockwise rotation will increase the chopper reference voltage and also the output voltage.

After the correct setting has been obtained, several precision AC to DC transfers should be made to insure the output voltage accuracy. This is important since this adjustment affects all output voltage settings of the Model 323A.

e. Attenuator Ratio Adjustment. Do not attempt to make this adjustment without precision standards equipment, or operation outside of specifications may result.

With the Model 323A operating at 1 kc and the output voltage set at two volts, after a one-half hour warmup, measure the output terminal voltage with a precision AC voltmeter. Be sure that all other decades are in the zero position, especially the vernier potentiometer. The voltage must be 2.000 ± 0.01%.

Before this two volt level can be adjusted, it is necessary that the one volt level be previously set as in step d. above. To adjust the two volt level, adjust R704 located on the AC-DC converter assembly. Clockwise rotation will increase the output voltage.

After the correct setting has been obtained, several precision AC to DC transfers should be made to insure the output voltage accuracy. This is important since this adjustment sets the ratio between the attenuator and the converter input, and consequently affects all the absolute output voltages above one volt.

f. AC-DC Converter High Frequency Compensation. With the Model 323A operating at 1 kc and the output voltage set at ten volts, obtain a null on the precision AC voltmeter. Change the input frequency in increments up to 20 kc. The output voltage should be within ± ~~0.010~~ 0.03% up to 10 kc, and within ± ~~0.025~~% up to 20 kc.

To adjust the high frequency compensation, adjust C709 located on the AC-DC converter assembly. Recheck the incremental frequencies to insure the accuracy of this adjustment. This compensation must be accurately adjusted because it will affect the high frequency response of all output voltages by the same percentage. The adjustment of C709 does not affect the absolute output voltage at 1 kc and therefore will not affect the absolute adjustment in step d. above.

g. AC-DC Converter Low Frequency Compensation. With the Model 323A operating at 1 kc and the output voltage set at 10 volts, obtain a null on the precision AC voltmeter. Change the input frequency in increments down to 35 cps. The output voltage should be within ± 0.025% down to 100 cps, and within ± 0.040% down to 35 cps.

To adjust the low frequency compensation, adjust R721 located on the AC-DC converter assembly. Recheck the incremental frequencies to insure the accuracy of this adjustment. This compensation must be accurately adjusted because it will affect the low frequency response of all output voltages by the same percentage. The adjustment of R721 does not affect the absolute output voltage at 1 kc and therefore will not affect the absolute adjustment in step d. above.

h. With 1 kc internal oscillator frequency selected, adjust C225 for 1 kc within ± 1/2%.

With 50 cps internal oscillator frequency selected, adjust C227 for 50 cps ± 1/2%.

SECTION 5
SERVICING

5.1 Voltage Measurements

As a convenience for maintenance personnel, all of the information required to troubleshoot the Model 323 is supplied on the schematic diagrams. This eliminates the tiresome paging required when voltage charts are used. Wave forms, when required, will also be found on the schematics.

5.2 Conditions for Voltage Measurements

The voltage measurements and the wave forms are all taken with the equipment operating under the following conditions (unless specified otherwise on the schematic diagram).

(1) Input signal level is 1.0 volt RMS at 1 KC at the input terminals. An external oscillator is used.

(2) A 15 voltampere load is applied to the output terminals.

(3) The Output Voltage Selector is set to deliver 45 volts.

(4) Unit is in the OPERATE position.

5.3 DC Voltage Measurements

All DC voltage measurements are printed in blue on the schematics. Readings are taken with a VTVM having an input resistance of 11 megohms. Readings are taken with reference to common. Values shown are ± 20% unless otherwise specified on the schematic.

5.4 AC Measurements and Wave Forms

All AC measurements are printed in red on the schematics. Readings are all peak to peak values measured with a 10 megohm oscilloscope probe. All readings taken with reference to common. Values shown are ± 10% unless otherwise specified on the schematic.

5.5 Component Locations

Components are labeled uniformly on schematics, parts lists, and illustrations. Location of a part can be determined by referring to the parts list. The number of the illustration showing the desired part is listed in the right hand column.

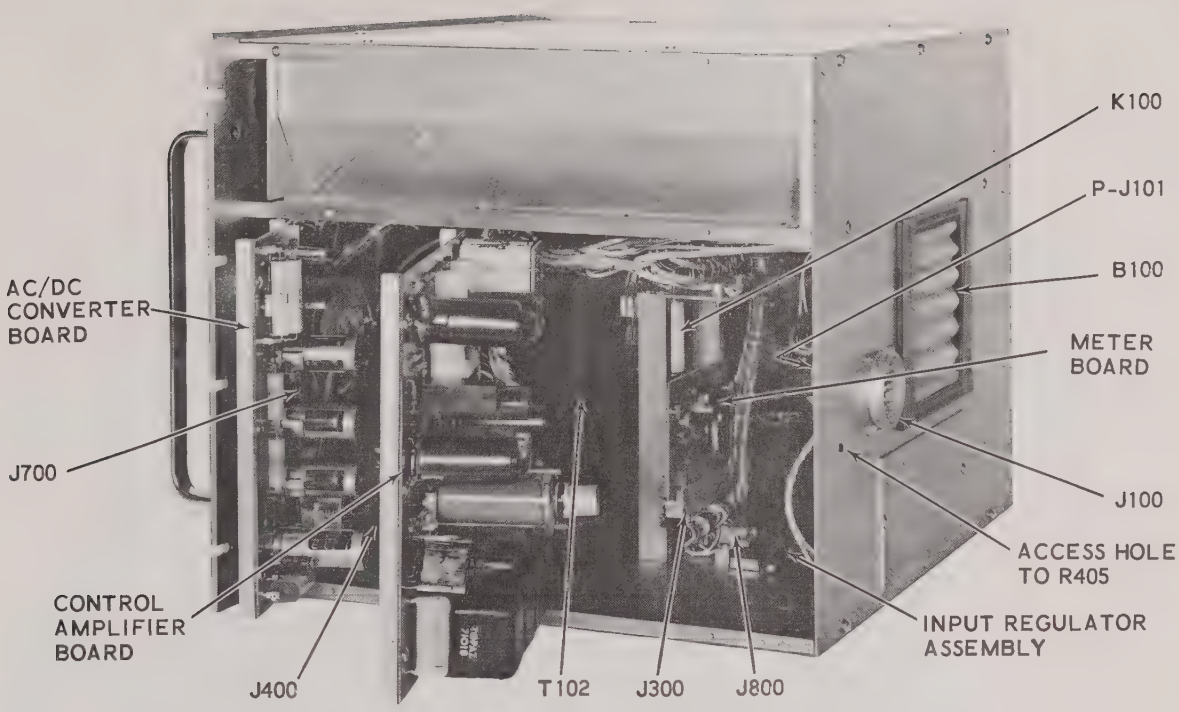


Figure 18. Regulator Assembly (Right Side)

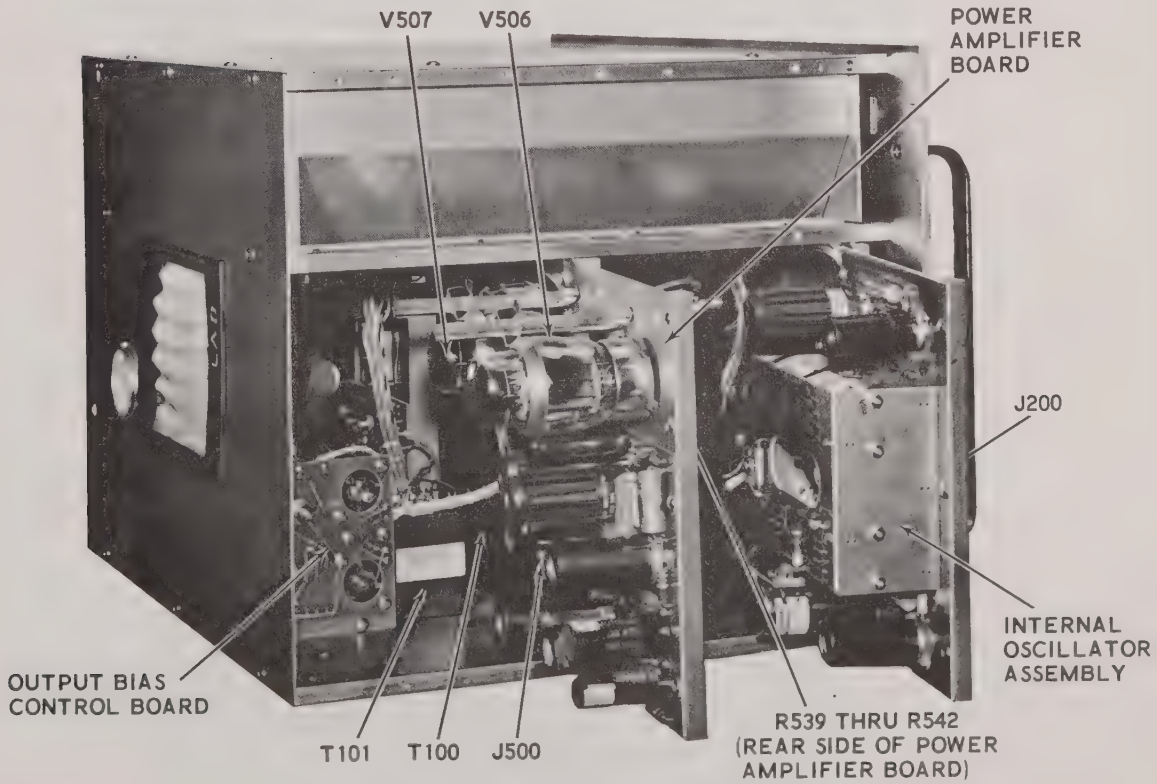


Figure 19. Regulator Assembly (Left Side)

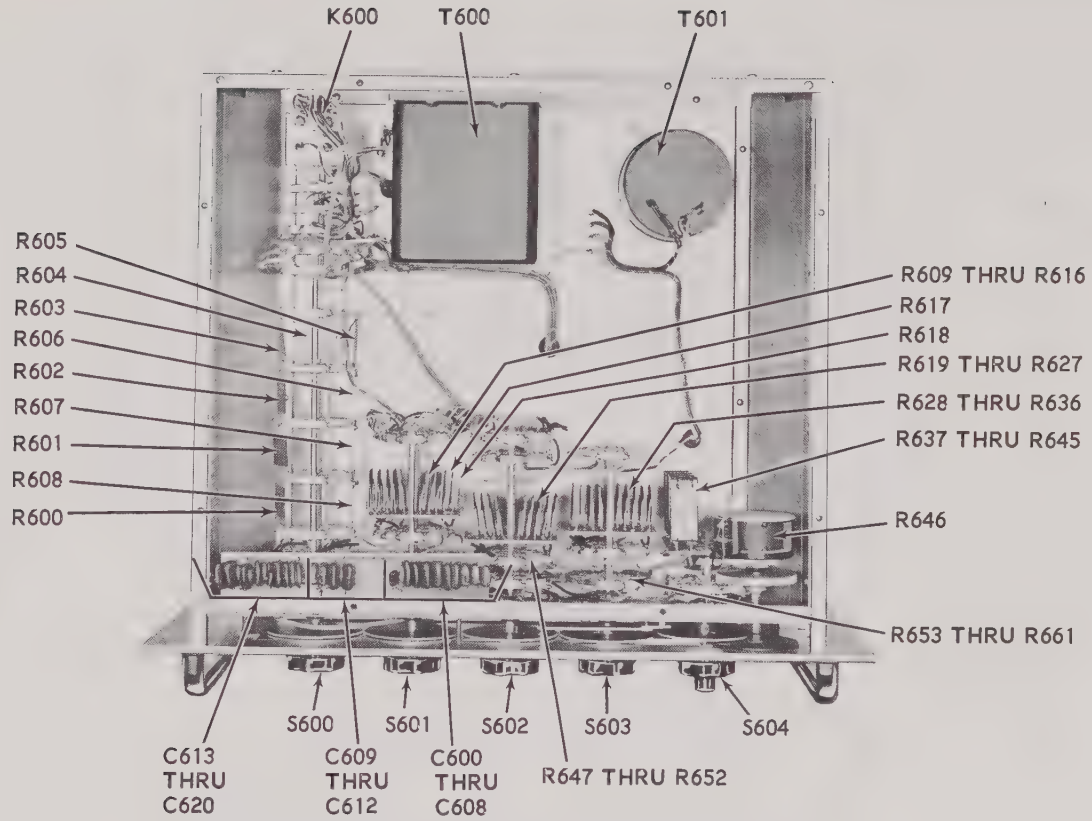


Figure 20. Regulator Assembly (Top View - Attenuator Assembly)

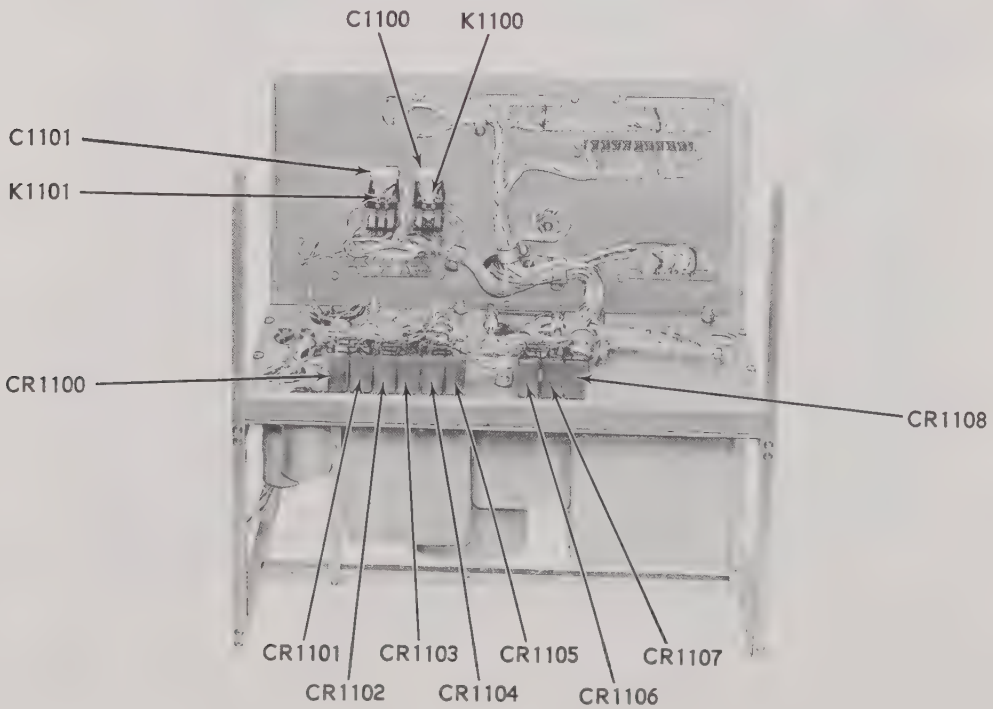


Figure 21. Power Supply - Wiring Channel

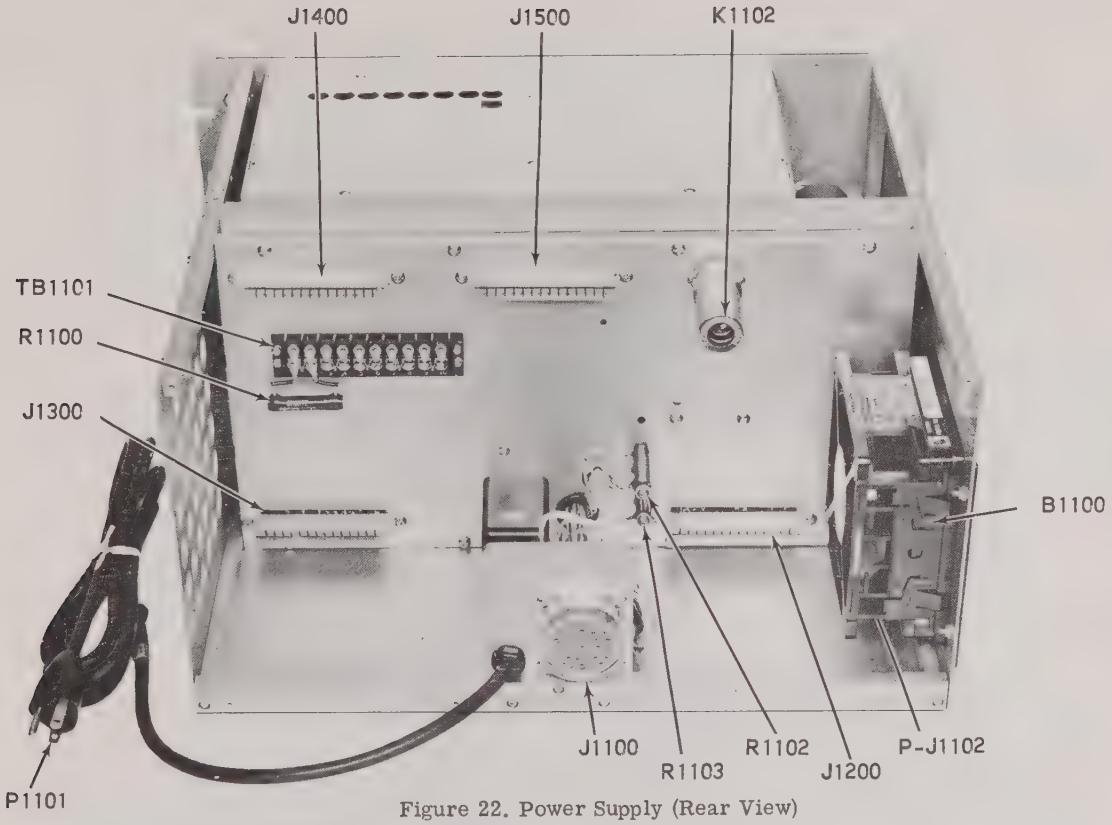


Figure 22. Power Supply (Rear View)

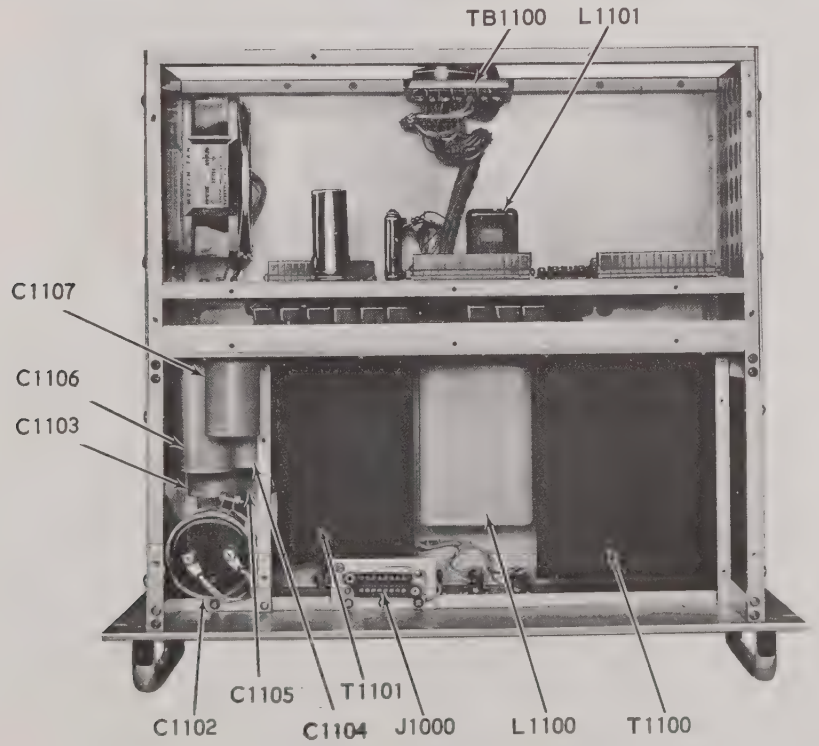


Figure 23. Power Supply (Top View - Reference Pack Removed)

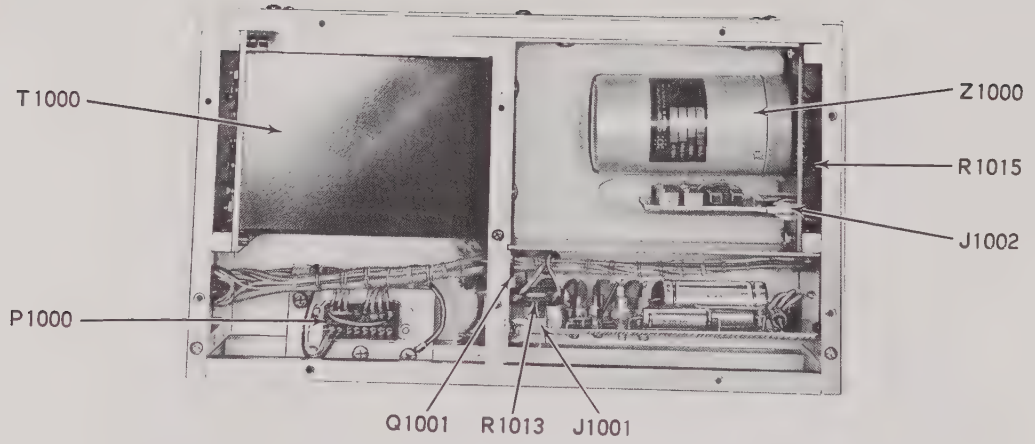


Figure 24. Reference Pack Assembly

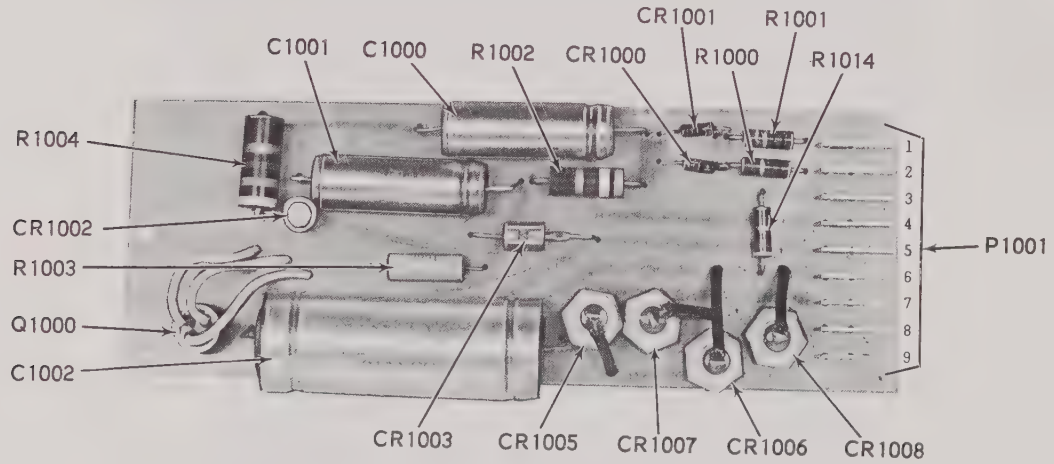


Figure 25. Reference Pack Power Supply Board

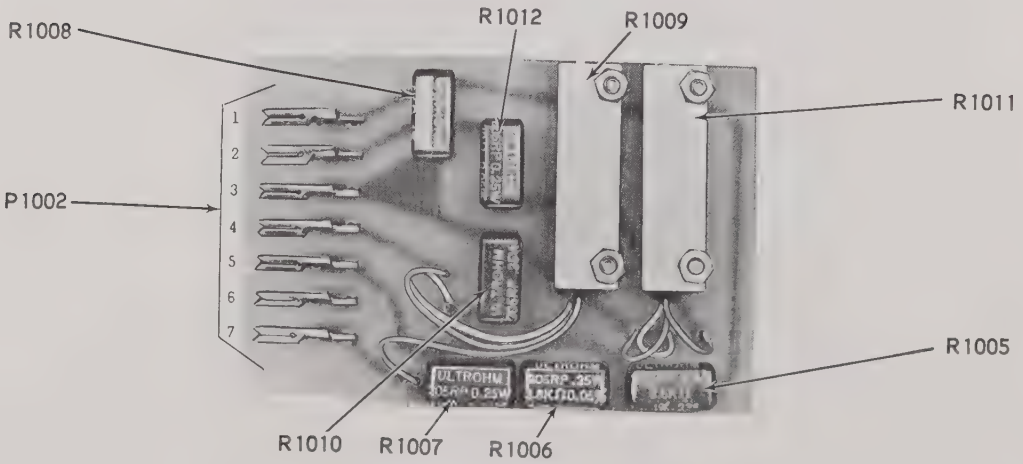


Figure 26. Reference Pack Resistor Board

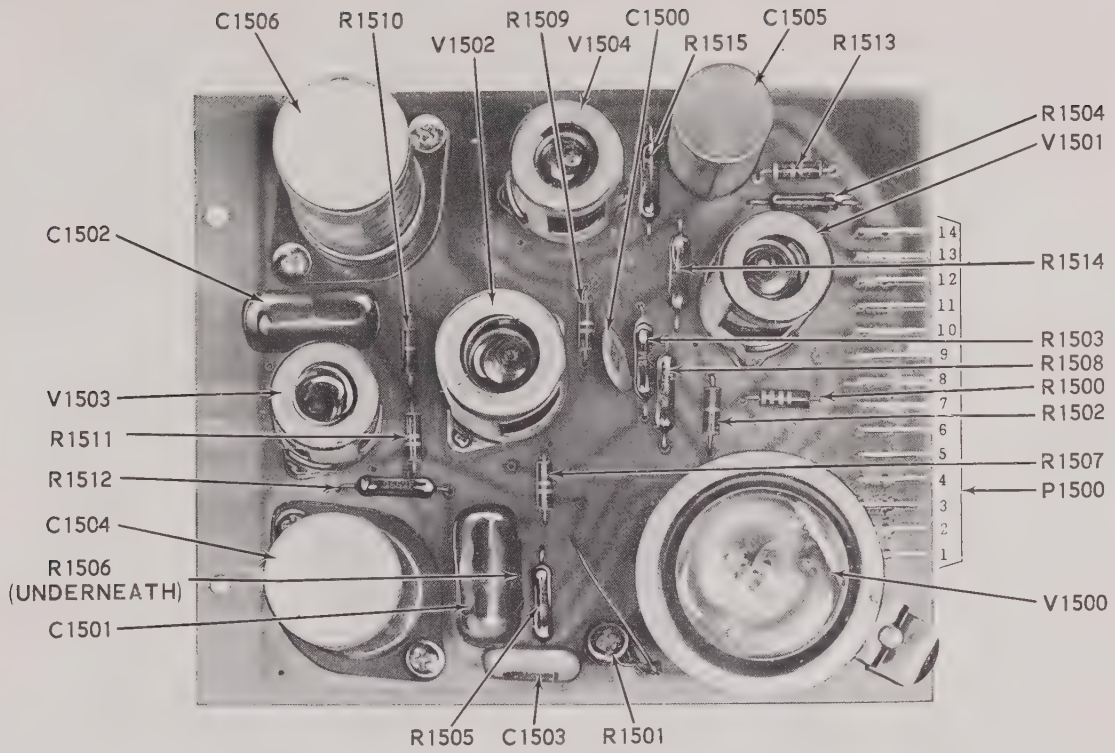


Figure 27. Power Supply Regulator Board (-150 and -380 volt Supply)

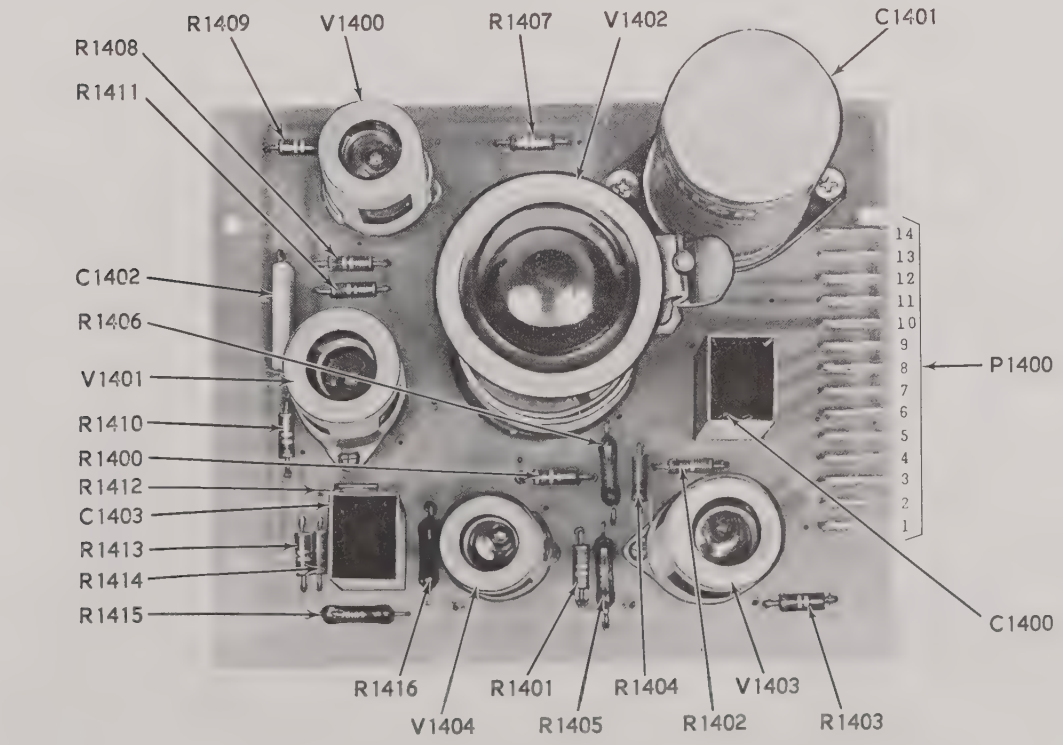


Figure 28. Power Supply Regulator Board (+150 and +250 volt Supply)

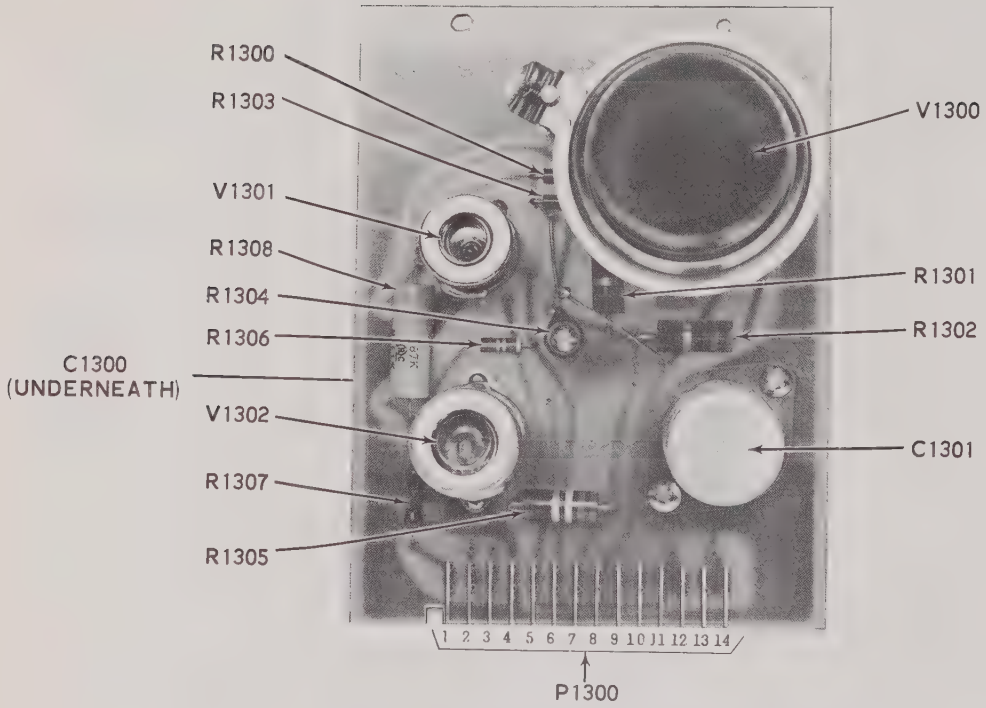


Figure 29. Power Supply Regulator Board (+450 volt Supply)

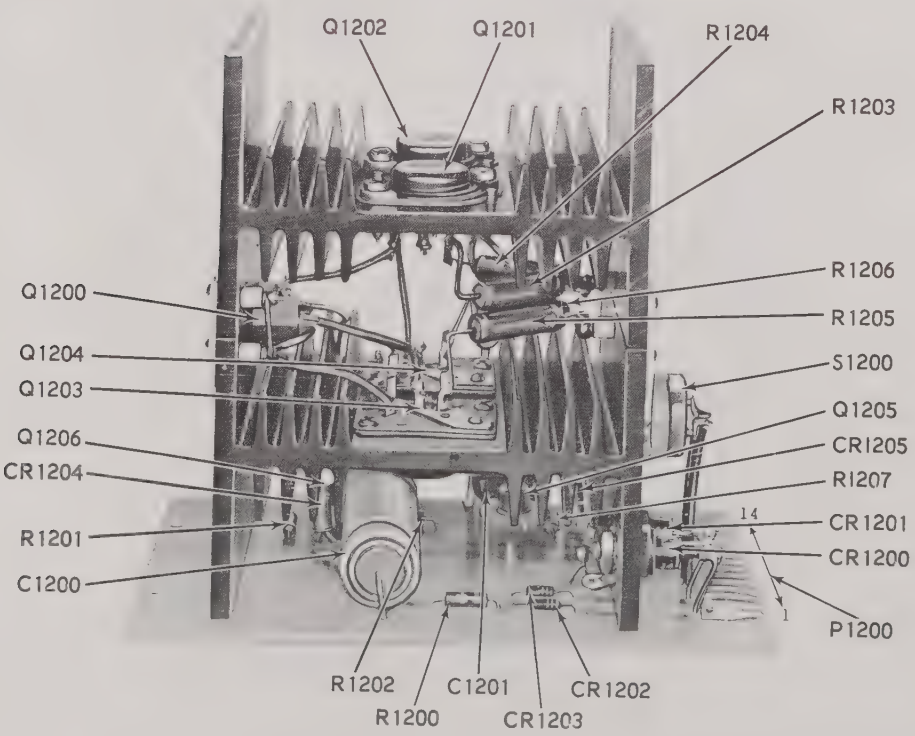


Figure 30. Power Supply Regulator Assembly (6 volt DC Supply)

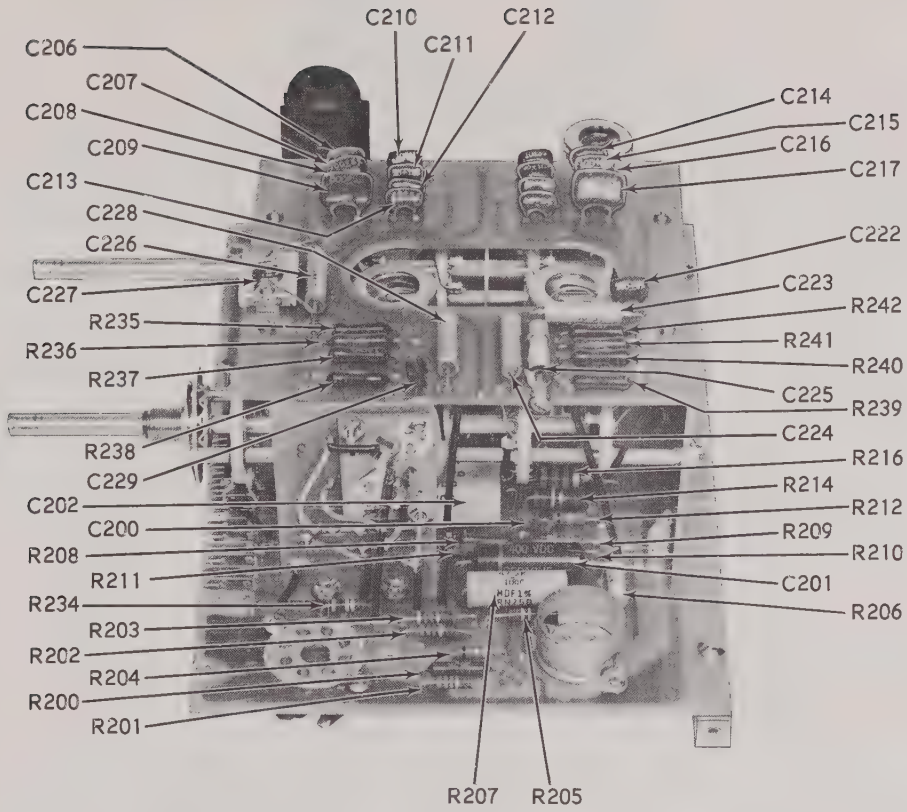


Figure 31. Internal Oscillator Assembly (Right Hand View)

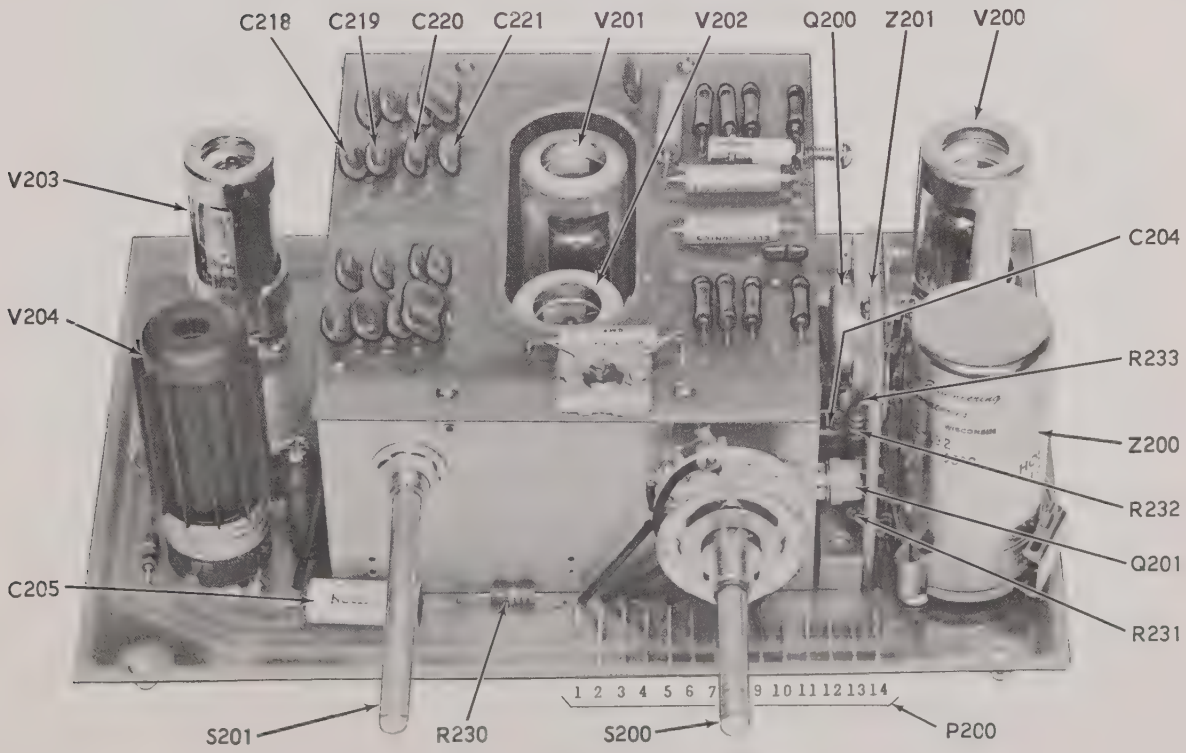


Figure 32. Internal Oscillator Assembly (Front View)

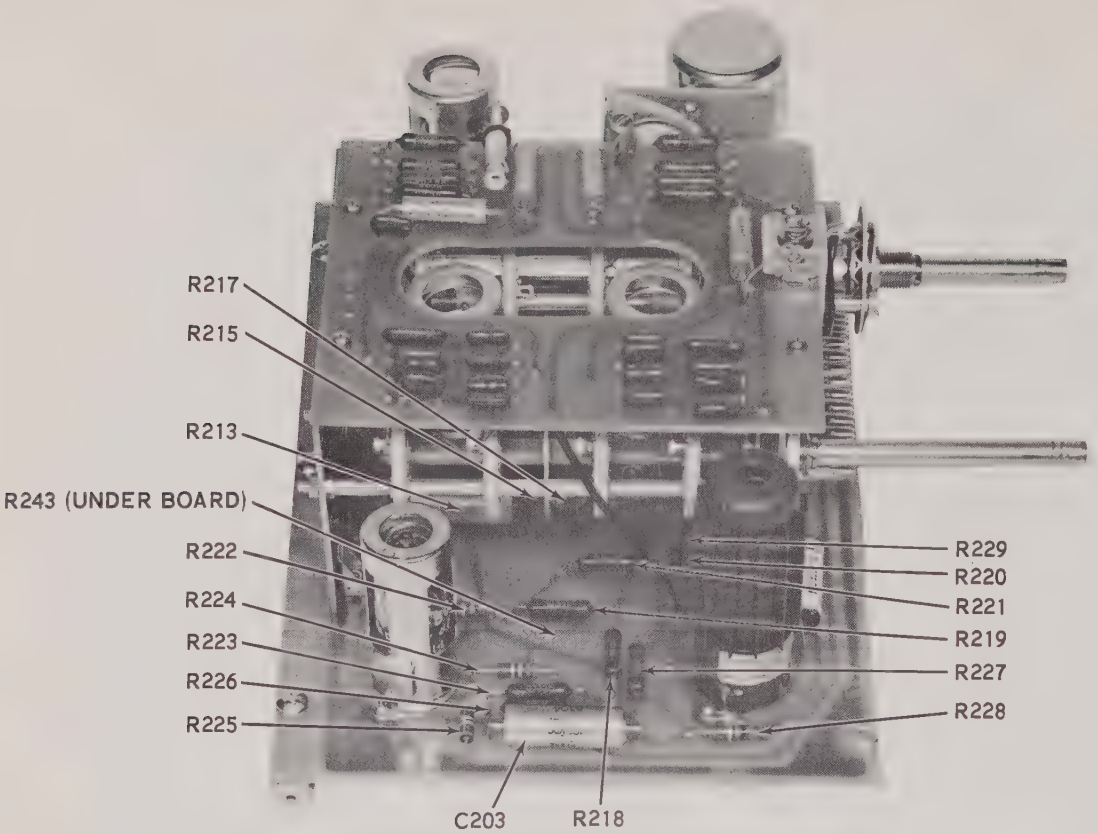


Figure 33. Internal Oscillator Assembly (Left Hand View)

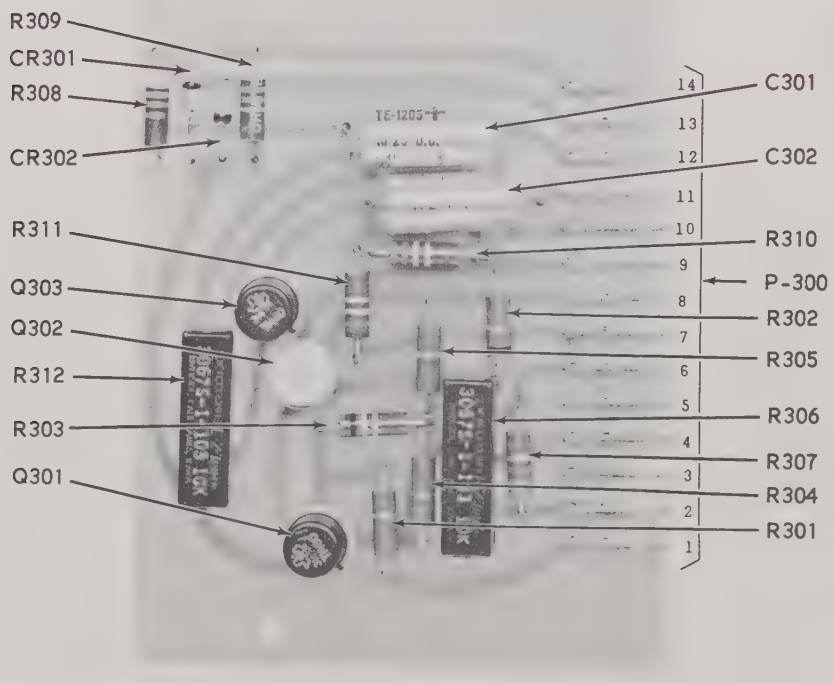


Figure 34. Meter Board

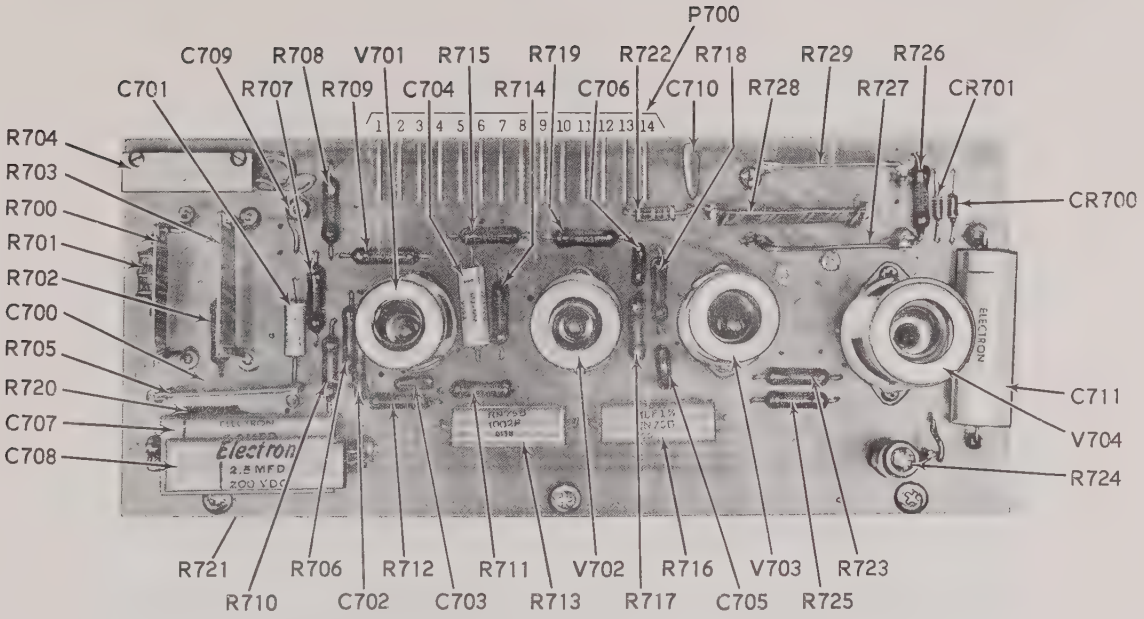


Figure 35. AC to DC Converter Board

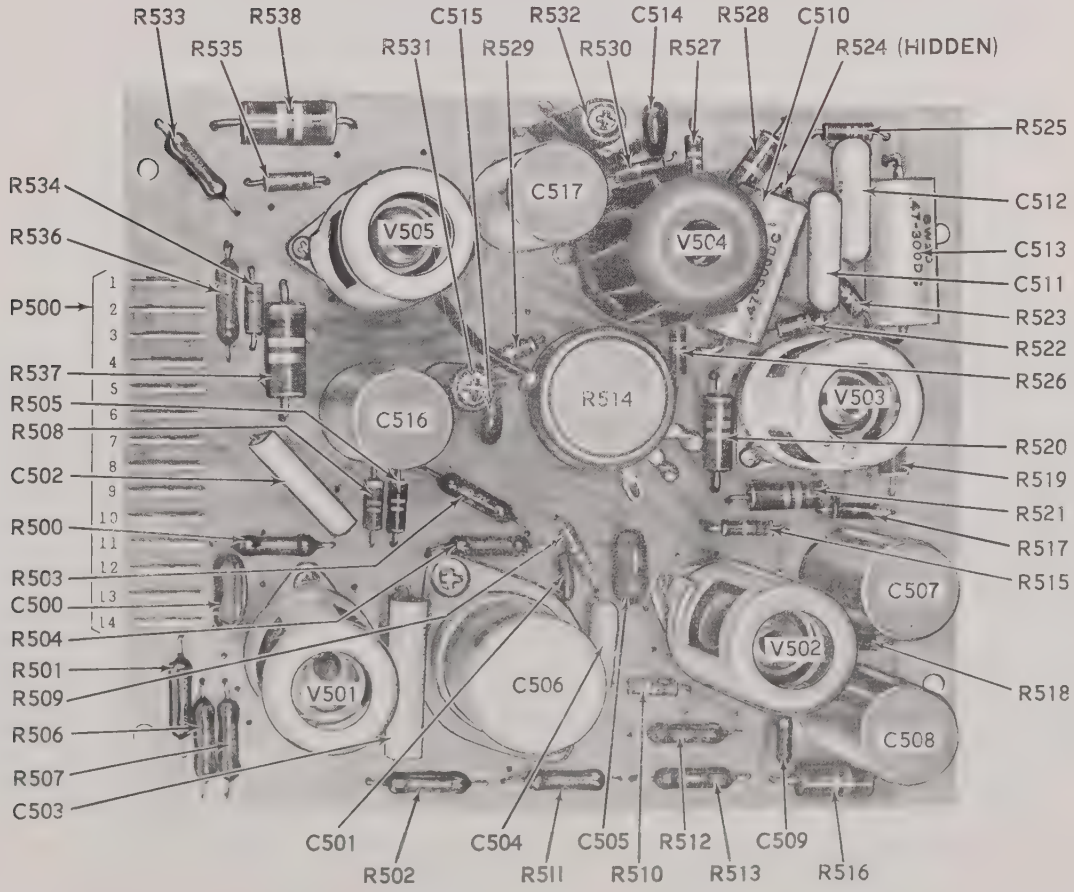


Figure 36. Power Amplifier Board

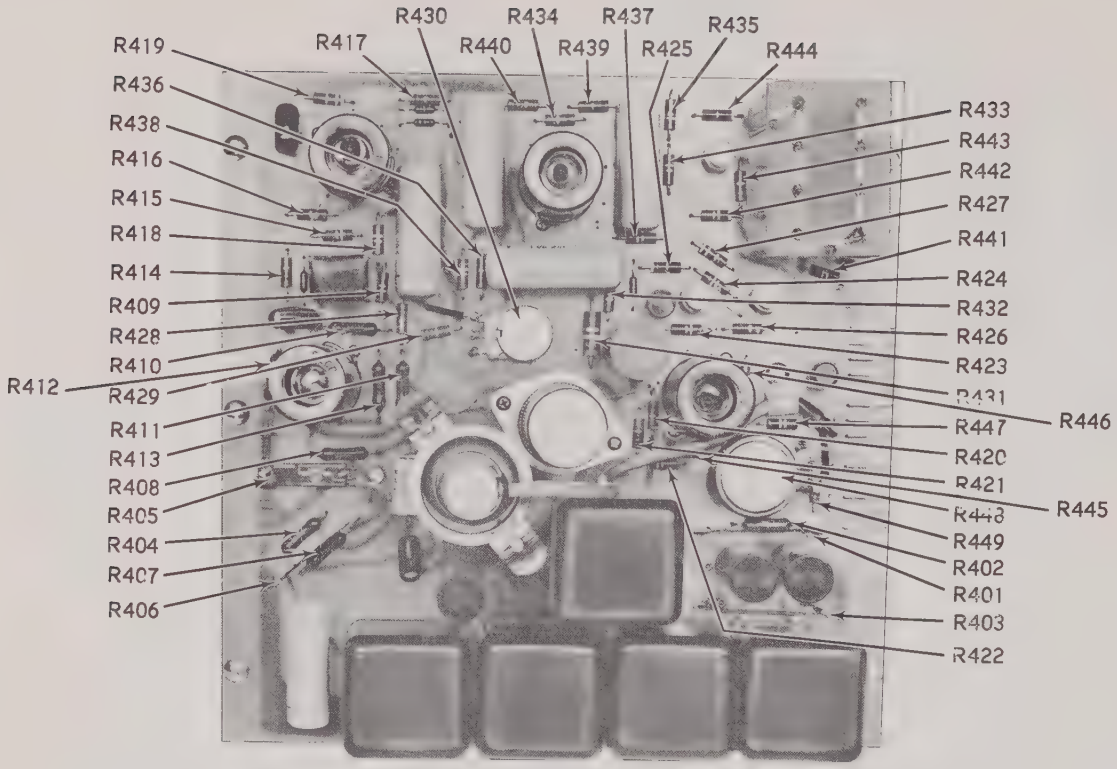


Figure 37A. Control Amplifier Board - Resistor Locations

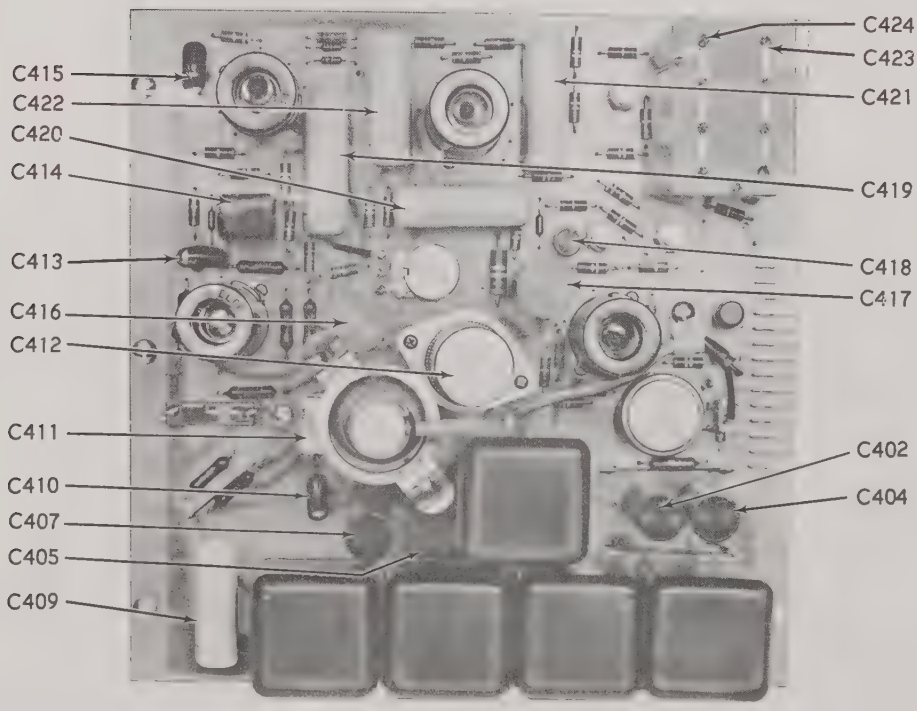


Figure 37B. Control Amplifier Board - Capacitor Locations

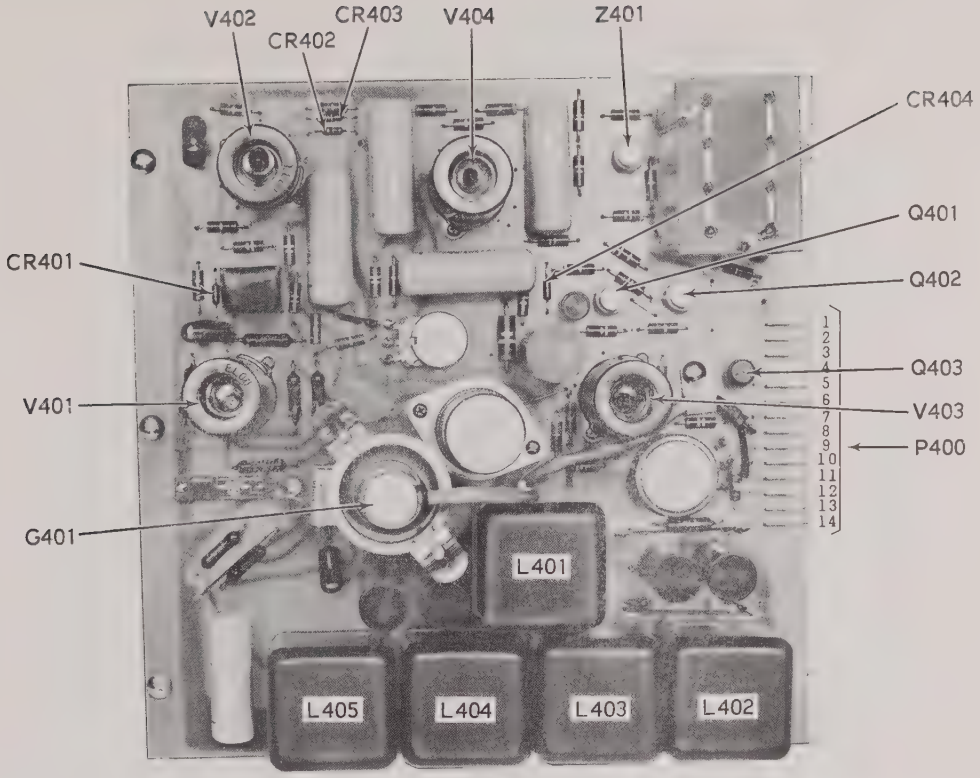


Figure 37C. Control Amplifier Board - Miscellaneous Parts Location

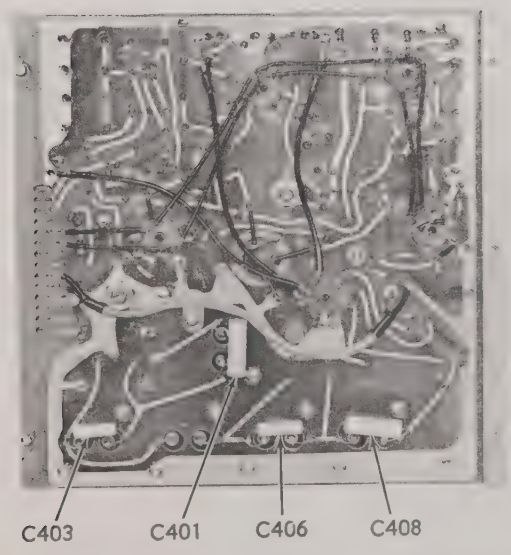


Figure 38. Control Amplifier Board (Back View)

Figure 39. Input Regulator Assembly

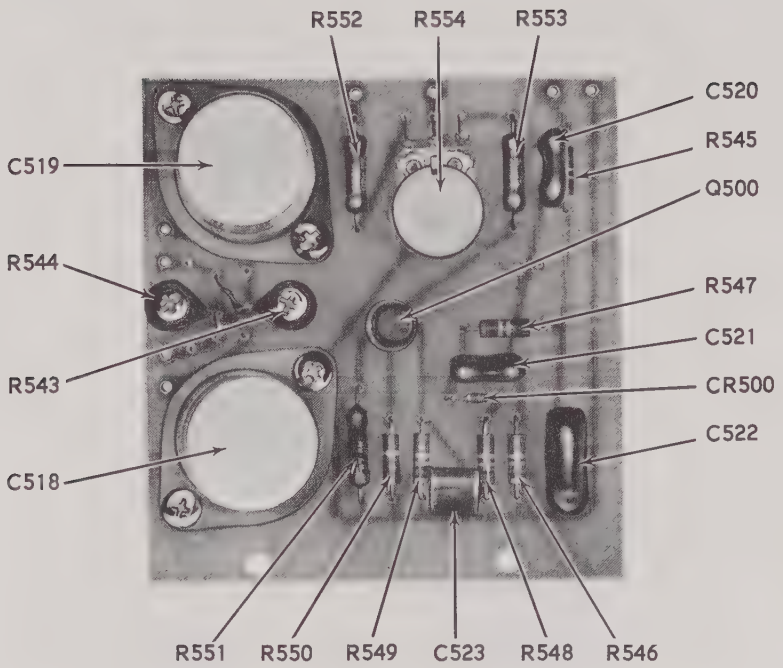


Figure 40. Bias Control Board

SECTION 6
LIST OF REPLACEABLE PARTS

6.1 Part Numbers

a. General. The part numbers have been chosen to aid the service personnel in locating parts. The parts in the regulator assembly are numbered in the hundreds. The parts in the power supply assembly are labeled in the thousands. The paragraphs that follow list the parts locations on the schematic diagrams.

b. Regulator Assembly. Parts in the regulator assembly are labeled according to the following system:

SCHEMATIC TITLE	SERIES NUMBER
Regulator interconnection	100
Internal oscillator	200
Meter	300
Control amplifier	400
Power amplifier	500
Voltage switching and attenuator	600
AC/DC converter	700
Input regulator	800

c. Power Supply Assembly. Parts in the power supply are labeled according to the following system:

SCHEMATIC TITLE	SERIES NUMBER
Reference supply	1000
Power supply interconnection	1100
Filament supply	1200
High voltage supply (+450 volts)	1300
High voltage supply (+150 and +250 volts)	1400
High voltage supply (-85, -150 and -380 volts)	1500

6.2 Parts Description

A complete description and the Holt part number is supplied for each replaceable part. When ordering parts, give the complete description, the Holt part number, the reference number, the model number, and the serial number of the equipment. Holt Part Numbers that begin with the number 5XXXX are manufactured or modified by Holt and must be purchased from Holt.

6.3 Parts Illustrations

The location of each part in the illustrations in the manual is simplified by the use of the right hand column on the parts pages titled LOCATION - FIGURE NO. The figure number of the illustration in which this part is shown will appear in this column.

LIST OF REPLACEABLE PARTS
AUDIO VOLTAGE STANDARD - MODEL 323A

Circuit Reference	Description	Holt Part Number	Location Figure No.
B100	Fan, Tube, Axial, 1 Phase, 100 CFM 115 VAC, 60 cps, 14 Watt, (W/filter box and grill)	12421-001	18
B1100	Fan, Tube, Axial, 1 Phase, 100 CFM 115 VAC, 60 cps, 14 Watt, (W/filter and grill)	12421-001	22
C100	Capacitor, Fixed, Metallized Paper 1 MFD, 100 V, ± 20%	10553-105	
C200	Capacitor, Fixed, Dur-Mica 51 pf, 500 VDC, ± 10%	10516-510	31
C201	Capacitor, Fixed, Mylar Paper .05 MFD, 400 VDC, ± 10%	10515-503	31
C202	Capacitor, Fixed, Metallized Paper 10 MFD, 100 VDC, ± 20%	0902-030	31
C203	Capacitor, Fixed, Metallized Paper .1 MFD, 400 VDC, ± 20%	10533-104	33
C204	Part of Z201		32
C205	Capacitor, Fixed, Metallized Paper 1.5 MFD, 100 VDC, ± 20%	0902-031	32
C206	Capacitor, Fixed, Dur-Mica 200 pf, 500 VDC, ± 5%	10596-201	31
C207	Capacitor, Fixed, Dur-Mica 400 pf, 500 VDC, ± 5%	10596-401	31
C208	Capacitor, Fixed, Dur-Mica 600 pf, 500 VDC, ± 5%	10596-601	31
C209	Capacitor, Fixed, Dur-Mica 800 pf, 500 VDC, ± 5%	10596-801	31
C210	Capacitor, Fixed, Dur-Mica 10 pf, 500 VDC, ± 5%	10596-100	31
C211	Capacitor, Fixed, Dur-Mica 20 pf, 500 VDC, ± 5%	10596-200	31
C212	Capacitor, Fixed, Dur-Mica 30 pf, 500 VDC, ± 5%	10596-300	31
C213	Capacitor, Fixed, Dur-Mica 40 pf, 500 VDC, ± 5%	10596-400	31
C214	Capacitor, Fixed, Dur-Mica 200 pf, 500 VDC, ± 5%	10596-201	31
C215	Capacitor, Fixed, Dur-Mica 400 pf, 500 VDC, ± 5%	10596-401	31

LIST OF REPLACEABLE PARTS

Circuit Reference	Description	Holt Part Number	Location Figure No.
C216	Capacitor, Fixed, Dur-Mica 600 pf, 500 VDC, ± 5%	10596-601	31
C217	Capacitor, Fixed, Dur-Mica 800 pf, 500 VDC, ± 5%	10596-801	31
C218	Capacitor, Fixed, Dur-Mica 10 pf, 500 VDC, ± 5%	10596	32
C219	Capacitor, Fixed, Dur-Mica 20 pf, 500 VDC, ± 5%	10596-200	32
C220	Capacitor, Fixed, Dur-Mica 30 pf, 500 VDC, ± 5%	10596-300	32
C221	Capacitor, Fixed, Dur-Mica 40 pf, 500 VDC, ± 5%	10596-400	32
C222 *	Capacitor, Fixed, Dur-Mica 100 pf, 500 VDC, ± 20%	10636-101	31
C223	Capacitor, Fixed, Mylar .009 MFD, 100 VDC, ± 1%	10655-902	31
C224	Capacitor, Fixed, Mylar 450 pf, 100 VDC, ± 1%	10626-451	31
C225	Capacitor, Variable 1.5 - 10 pf	10558-100	31
C226	Capacitor, Fixed, Mylar .009 MFD, 100 VDC, ± 1%	10655-902	31
C227	Capacitor, Variable 9 - 180 pf	10666-181	31
C228	Capacitor, Fixed, Mylar 450 pf, 100 VDC, ± 1%	10626-451	31
C229 *	Capacitor, Fixed, Dur-Mica 5 pf, 500 VDC, ± .5 pf	10656-050	31
C301	Capacitor, Fixed, Electrolytic 15 MFD, 25 VDC	10611-156	34
C302	Capacitor, Fixed, Electrolytic 15 MFD, 25 VDC	10611-156	34
C401	Capacitor, Fixed, Mylar .22 MFD, 100 VDC, ± 1%	10585-224	38
C402	Capacitor, Fixed, Mylar .275 MFD, 50 VDC, ± 1%	10605-274	37B
C403	Capacitor, Fixed, Mylar .043 MFD, 100 VDC, ± 1%	10585-433	38
C404	Capacitor, Fixed, Mylar .35 MFD, 500 VDC, ± 1%	10615-354	37B

* Factory Selected Value, Nominal Value Shown.

LIST OF REPLACEABLE PARTS

Circuit Reference	Description	Holt Part Number	Location Figure No.
C405	Capacitor, Fixed, Mylar .35 MFD, 50 VDC, ± 1%	10615-354	37B
C406	Capacitor, Fixed, Mylar .043 MFD, 100 VDC, ± 1%	10585-433	38
C407	Capacitor, Fixed, Mylar .275 MFD, 50 VDC, ± 1%	10605-274	37B
C408	Capacitor, Fixed, Mylar .22 MFD, 100 VDC, ± 1%	10585-224	38
C409	Capacitor, Fixed, Mylar .47 MFD, 100 VDC, ± 10%	0903-056	37B
C410	Capacitor, Fixed, Mylar Paper .006 MFD, 600 VDC, ± 10%	10545-602	37B
C411	Capacitor, Fixed, Metallized Paper .5 MFD, 200 VDC, ± 20%	10513-504	37B
C412	Capacitor, Fixed, Electrolytic, Dual 20-20 MFD, 350-350 VDC	10751-206	37B
C413	Capacitor, Fixed, Mylar Paper .003 MFD, 600 VDC, ± 10%	10545-302	37B
C414	Capacitor, Fixed, Metallized Paper 1 MFD, 400 VDC, ± 20%	10603-105	37B
C415	Capacitor, Fixed, Mylar Paper .01 MFD, 400 VDC, ± 10%	10525-103	37B
C416	Capacitor, Fixed, Tubular Paper .22 MFD, 600 VDC	10544-224	37B
C417	Capacitor, Fixed, Tubular Paper .22 MFD, 600 VDC	10544-224	37B
C418	Capacitor, Fixed, Electrolytic 5 MFD, 15 VDC	10801-505	37B
C419 thru C422	Capacitor, Fixed, Mylar .5 MFD, 400 VDC, ± 10%	10645-504	37B
C423 a,b,c,d	Capacitor, Fixed, Metallized Paper 10 MFD, 100 VDC, ± 20%	10553-106	37B
C424 a,b,c,d	Capacitor, Fixed, Metallized Paper 10 MFD, 100 VDC, ± 20%	10553-106	37B
C500	Capacitor, Fixed, Dur-Mica 1200 pf, 500 VDC, ± 10%	10526-122	36
C501	Capacitor, Fixed, Dur-Mica 82 pf, 500 VDC, ± 10%	10516-820	36
C502	Capacitor, Fixed, Metallized Paper .50 MFD, 200 VDC, ± 20%	0902-032	36

LIST OF REPLACEABLE PARTS

Circuit Reference	Description	Holt Part Number	Location Figure No.
C503	Capacitor, Fixed, Metallized ~~Paper~~ MYLAR 1.0 MFD, 200 VDC, ± 20%	0904-004 0902-033	36
C504	Capacitor, Fixed, Mylar Paper .022 MFD, 200 VDC, ± 10%	10675-223	36
C505	Capacitor, Fixed, Mylar Paper .0047 MFD, 600 VDC, ± 10%	10545-472	36
C506	Capacitor, Fixed, Electrolytic 50 MFD, 150 VDC, -10% +100%	10521-506	36
C507	Capacitor, Fixed, Tubular Paper .22 MFD, 600 VDC	10544-224	36
C508	Capacitor, Fixed, Tubular Paper .22 MFD, 600 VDC	10544-224	36
C509	Capacitor, Fixed, Dur-Mica 24 pf, 500 VDC, ± 10%	10516-240	36
C510	Capacitor, Fixed, Metallized Mylar .47 MFD, 300 VDC, ± 20%	10613-474	36
C511	Capacitor, Fixed, Mylar Paper .05 MFD, 400 VDC, ± 10%	10645-503	36
C512	Capacitor, Fixed, Mylar Paper .05 MFD, 400 VDC, ± 10%	10645-503	36
C513	Capacitor, Fixed, Metallized Mylar .47 MFD, 300 VDC, ± 20%	10613-474	36
C514	Capacitor, Fixed, Dur-Mica 240 pf, 500 VDC, ± 10%	10516-241	36
C515	Capacitor, Fixed, Dur-Mica 240 pf, 500 VDC, ± 10%	10516-241	36
C516	Capacitor, Fixed, Tubular Paper .22 MFD, 600 VDC	10544-224	36
C517	Capacitor, Fixed, Tubular Paper .22 MFD, 600 VDC	10544-224	36
C518	Capacitor, Fixed, Electrolytic 500 MFD, 25 VDC	10811-507	
C519	Capacitor, Fixed, Electrolytic 500 MFD, 25 VDC	10811-507	
C520	Capacitor, Fixed, Dur-Mica 1500 pf, 500 VDC, ± 5%	10556-152	
C521	Capacitor, Fixed, Dur-Mica 1500 pf, 500 VDC, ± 5%	10556-152	
C522	Capacitor, Fixed, Mylar Paper .1 MFD, 100 VDC, ± 10%	10505-104	
C523	Capacitor, Fixed, Electrolytic 5 MFD, 15 VDC, -10% +150%	10801-505	
	CAPACITOR, FIXED, DUR-MICA 91 pf. 500 VDC ± 5%	0907-036	

C600*	Capacitor, Fixed, Dur-Mica 680 pf, 300 VDC, ± 5%	0907-079
C601*	Capacitor, Fixed, Dur-Mica 10 pf, 500 VDC, ± 5%	0907-025
C602*	Capacitor, Fixed, Dur-Mica 800 pf, 500 VDC, ± 5%	0907-010
C603*	Capacitor, Fixed, Dur-Mica 910 pf, 500 VDC, ± 5%	0907-012
C604*	Capacitor, Fixed, Dur-Mica 1300 pf, 500 VDC, ± 5%	0907-015
C605*	Capacitor, Fixed, Dur-Mica 1600 pf, 500 VDC, ± 5%	0907-017
C606*	Capacitor, Fixed, Dur-Mica 2400 pf, 500 VDC, ± 5%	0907-020
C607*	Capacitor, Fixed, Mylar Paper .0047 MFD, 600 VDC, ± 10%	0903-047
C608*	Capacitor, Fixed, Mylar Paper .01 MFD, 100 VDC, ± 10%	0903-004
C609*	Capacitor, Fixed, Dur-Mica 2000 pf, 500 VDC, ± 5%	0907-018
C610*	Capacitor, Fixed, Dur-Mica 1600 pf, 500 VDC, ± 5%	0907-017
C611*	Capacitor, Fixed, Dur-Mica 1300 pf, 500 VDC, ± 5%	0907-015
C612*	Capacitor, Fixed, Dur-Mica 800 pf, 500 VDC, ± 5%	0907-010
C613*	Capacitor, Fixed, Dur-Mica 1600 pf, 500 VDC, ± 5%	0907-017
C614*	Capacitor, Fixed, Dur-Mica 1500 pf, 500 VDC, ± 5%	0907-016
C615*	Capacitor, Fixed, Dur-Mica 1300 pf, 500 VDC, ± 5%	0907-015
C616*	Capacitor, Fixed, Dur-Mica 1200 pf, 500 VDC, ± 5%	0907-014
C617*	Capacitor, Fixed, Dur-Mica 910 pf, 500 VDC, ± 5%	0907-012
C618*	Capacitor, Fixed, Dur-Mica 500 pf, 500 VDC, ± 5%	0907-003
C619*	Capacitor, Fixed, Dur-Mica 27 pf, 500 VDC, ± 5%	0907-032

* Factory selected, Typical value shown.

LIST OF REPLACEABLE PARTS

Circuit Reference	Description	Holt Part Number	Location Figure No.
C620 * C621*	Capacitor, Fixed, Dur-Mica ~~5~~ 10 pf, 500 VDC, ± ~~.5 pf~~ 5%	~~10656-050~~ 0902-025	20
C700 *	Capacitor, Fixed, Dur-Mica 68 pf, 500 VDC, ± 10%	10516-680	35
C701	Capacitor, Fixed, Metallized ~~Paper~~ MYLAR .25 MFD, ~~100~~ 200 VDC, ± 20%	0904 ~~0902-006~~	35
C702	Capacitor, Fixed, Dur-Mica 1500 pf, 500 VDC, ± 10%	10526-152	35
C703	Capacitor, Fixed, Dur-Mica 100 pf, 500 VDC, ± 10%	10516-101	35
C704	Capacitor, Fixed, Metallized Paper .50 MFD, 200 VDC, ± 20%	0902-032	35
C705	Capacitor, Fixed, Dur-Mica 470 pf, 500 VDC, ± 10%	10526-471	35
C706	Capacitor, Fixed, Dur-Mica 12 pf, 500 VDC, ± 10%	10516-120	35
C707	Capacitor, Fixed, Metallized ~~Paper~~ MYLAR 5 MFD, 200 VDC, ± 20%	0904-005 ~~10513-505~~	35
~~C708~~ 4.5	~~Capacitor, Fixed, Metallized Paper 2.5 MFD, 200 VDC, ± 20%~~	~~10513-255~~	~~35~~
C709	Capacitor, Variable, ~~Ceramic~~ GLASS Tube 1 - ~~7.5~~ 9 pf, ~~600~~ 750 VDC	0908-009 ~~10528-000~~	35
C710	Capacitor, Fixed, Ceramic Disc .01 MFD, 600 VDC, GMV	10508-103	35
C711	Capacitor, Fixed, Metallized Mylar 5 MFD, 200 VDC, ± 5%	0904-003	35
C1000	Capacitor, Fixed, Electrolytic 15 MFD, 100 VDC	10711-156	25
C1001	Capacitor, Fixed, Electrolytic 15 MFD, 100 VDC	10711-156	25
C1002	Capacitor, Fixed, Electrolytic 500 MFD, 25 VDC	10741-507	25
C1100	Capacitor, Fixed, Mylar .05 MFD, 400 VDC, ± 10%	10645-503	21
C1101	Capacitor, Fixed, Mylar Paper .05 MFD, 400 VDC, ± 10%	10645-503	21
C1102	Capacitor, Fixed, Electrolytic 19,000 MFD, 25 VDC, (includes mounting clamps)	10651-199	23
C1103	Capacitor, Fixed, Electrolytic 125 MFD, 450 VDC, -10% +100%	10511-12A	23

* Factory Selected, Typical Value Shown.

Circuit Reference	Description	Holt Part Number	Location Figure No.
C1104	Capacitor, Fixed, Electrolytic 300 MFD, 150 VDC, -10% +100%	10521-307	23
C1105	Capacitor, Fixed, Electrolytic 250 MFD, 300 VDC, -10% +100%	10541-257	23
C1106	Capacitor, Fixed, Electrolytic 125 MFD, 350 VDC, -10% +100%	10691-12A	23
C1107	Capacitor, Fixed, Electrolytic 80 MFD, 350 VDC, -10% +100%	10691-806	23
C1200	Capacitor, Fixed, Electrolytic 500 MFD, 25 VDC	10741-507	30
C1201 *	Capacitor, Fixed, Mylar Paper ~~.100~~ 20 MFD, ~~100~~ 25 VDC, ± 10%	0705-077 ~~10505-104~~	30
C1300	Capacitor, Fixed, Ceramic .01 MFD, 600 VDC	10508-103	29
C1301	Capacitor, Fixed, Electrolytic 40 MFD, 500 VDC, -10% +100%	10681-406	29
C1400	Capacitor, Fixed, Metallized Paper 1.0 MFD, 400 VDC, ± 20%	10603-105	28
C1401	Capacitor, Fixed, Electrolytic, Dual 40-40 MFD, 450-450 VDC, -10% +100%	10501-406	28
C1402	Capacitor, Fixed, ~~Electrolytic, Dual~~ METALIZED PAPER .5 MFD, 200 VDC, ± 20%	0902-052 ~~10513-504~~	28
C1403	Capacitor, Fixed, Metallized Paper 1.0 MFD, 400 VDC, ± 20%	10603-105	28
C1404	Capacitor, Fixed, Dur-Mica 500 pf, 500 VDC, ± 5%	10516-501	
C1500	Capacitor, Fixed, Ceramic Disc .01 MFD, 600 VDC, GMV	10508-103	27
C1501	Capacitor, Fixed, Mylar Paper .1 MFD, 400 VDC, ± 10%	10525-104	27
C1502	Capacitor, Fixed, Mylar Paper .1 MFD, 400 VDC, ± 10%	10525-104	27
C1503	Capacitor, Fixed, Mylar Paper .02 MFD, 200 VDC, ± 10%	10625-203	27
C1504	Capacitor, Fixed, Electrolytic 40 MFD, 450 VDC	10511-406	27
C1505	Capacitor, Fixed, Tubular Paper .22 MFD, 600 VDC	10544-224	27
C1506	Capacitor, Fixed, Electrolytic 40 MFD, 450 VDC	10511-406	27

* Factory Selected, Typical Value Shown.

LIST OF REPLACEABLE PARTS

Circuit Reference	Description	Holt Part Number	Location Figure No.
CR301	Diode, Germanium, 85 PIV, 1N48	11402-004	34
CR302	Diode, Germanium, 85 PIV, 1N48	11402-004	34
CR303	Diode, Silicon, 36 PIV, 100 MA, 1N482	0301-017	
CR401 thru CR405	Diode, Silicon, Quick Recovery 125 PIV, 4 MA, 1N628	11411-003	37C
CR500	Diode, Silicon, Quick Recovery 125 PIV, 4 MA, 1N628	11411-003	
CR700	Diode, Silicon, 75 PIV, 75 MA, 1N916A	11531-010	35
CR701	Diode, Silicon, 75 PIV, 75 MA, 1N916A	11531-010	35
CR1000	Diode, Silicon, Quick Recovery 125 PIV, 4 MA, 1N628	11411-003	25
CR1001	Diode, Silicon, Quick Recovery 125 PIV, 4 MA, 1N628	11411-003	25
CR1002	Diode, Silicon, Zener Twin Anode 6.2 Volt Reference, 1N429	0303-004	25
CR1003	Diode, Silicon, Zener 30 Volt, ± 5%, 1N3031B	11444-012	25
CR1004 *	Part of Z1000		
CR1005 thru CR1008	Rectifier, Silicon, Stud Mounted 95 PIV, 1 Amp, 1N253	10406-006	25
CR1100	Rectifier, Silicon, Double 1000 PIV, 1.5 Amps, 2AB1	11415-006	21
CR1101	Rectifier, Silicon, Double 1000 PIV, 1.5 Amps, 2AB1	11415-006	21
CR1102 thru CR1105	Rectifier, Silicon, Double 500 PIV, 1.5 Amps, 1AB1	11405-006	21
CR1106	Rectifier, Silicon, Double 1000 PIV, 1.5 Amps, 2AB1	11415-006	21
CR1107	Rectifier, Silicon, Double 1000 PIV, 1.5 Amps, 2AB1	11415-006	21
CR1108	Rectifier, Silicon 2000 PIV, 750 MA, 4AB1	11471-006	21
CR1200	Rectifier, Silicon 50 PIV, 12 Amp, 1N1199A	11521-006	30
CR1201	Rectifier, Silicon 50 PIV, 12 Amp, 1N1199A	11521-006	30

* Factory Selected, Typical Value Shown.

LIST OF REPLACEABLE PARTS

Circuit Reference	Description	Holt Part Number	Location Figure No.
CR1202	Diode, Silicon, Quick Recovery 125 PIV, 4 MA, 1N628	11411-003	30
CR1203	Diode, Silicon, Quick Recovery 125 PIV, 4 MA, 1N628	11411-003	30
CR1204 *	Diode, Silicon, Zener, Twin Anode 6.2 Volt Reference, 5.9 Volt Min. Breakdown, 1N429	0303-004	30
CR1205 *	Diode, Silicon, Zener, Twin Anode 6.2 Volt Reference, 5.9 Volt Min. Breakdown, 1N429	0303-003	30
DS100 thru DS103	Lamp, Incandescent, Cartridge, T-1-3/4 .04 Amp, 6 Volts, White	0502-006	3
DS104 & DS105	Lamp, Incandescent, Cartridge, T-1-3/4 .2 Amp, 6 Volts, Red	0502-007	3
F1100	Fuse, 3 AB, 250 Volts, 12 Amp	13123-123	4
F1101	Fuse, 3 AG, Slo-Blo, 250 Volts, 1 Amp	13103-102	4
F1102	Fuse, 3 AG, Slo-Blo, 250 Volts, 4 Amp	13103-402	4
F1103	Fuse, 3 AG, Slo-Blo, 250 Volts, 3.2 Amp	1002-014	4
G401	Chopper	52729	37C
J100	Connector, Receptacle, 32 Contacts	12701-032	18
J101	Connector, Receptacle, 2 Contacts, 15 Amps	12751-002	18
J102	Terminal, Binding Post, Brass, Nylon Plastic Insulation, Black	12600-001	3
J103 thru J105	Terminal, Binding Post, Brass, Nylon Plastic Insulation, Red	12600-002	3
J106 & J107	Terminal, Binding Post, Brass, Nylon Plastic Insulation, Black	12600-001	3
J200	Connector, Receptacle, Precious Metal Contacts, 10 Amps, 14 Contacts	12721-014	19
J300	Connector, Receptacle, Precious Metal Contacts, 10 Amps, 14 Contacts	12721-014	18
J400	Connector, Receptacle, Precious Metal Contacts, 10 Amps, 14 Contacts	12721-014	18
J500	Connector, Receptacle, Precious Metal Contacts, 10 Amps, 14 Contacts	12721-014	19
J700	Connector, Receptacle, Precious Metal Contacts, 10 Amps, 14 Contacts	12721-014	18
J800	Connector, Receptacle, 10 Amps, 12 Contacts	12721-012	

* Factory Selected, Typical Value Shown.

LIST OF REPLACEABLE PARTS

Circuit Reference	Description	Holt Part Number	Location Figure No.
J1000	Connector, Receptacle, 750 VDC, 5 Amps, 16 Contacts	12731-026	23
J1001	Connector, Receptacle, 10 Amps, 9 Contacts	12721-009	24
J1002	Connector, Receptacle, Printed Board Standoff, 7 Contacts at 45°, 5 Amps	12741-007	24
J1100	Connector, Receptacle, Wall Mounting, 32 Contact	12711-032	22
J1102	Connector, Receptacle, Phenolic, 2 Contact, 15 Amps	12751-002	22
J1200	Connector, Receptacle, PCB, 10 Amps, 14 Contacts	12761-014	22
J1300	Connector, Receptacle, PCB, 10 Amps, 14 Contacts	12761-014	22
J1400	Connector, Receptacle, PCB, 10 Amps, 14 Contacts	12761-014	22
J1500	Connector, Receptacle, PCB, 10 Amps, 14 Contacts	12761-014	22
K100	Relay, Switching, 4PDT, 36 Ohms, 6 VDC	12535-004	18
K600	Relay, Switching, 4PDT, 36 Ohms, 6 VDC	12535-004	18
K1100	Relay, Switching, DPDT, Non-Inductive 8 Amps, 115 VAC, 60 cps	12505-002	21
K1101	Relay, Switching, 3PDT, Non-Inductive, 6 VDC	1203-008	21
K1102	Relay, Time Delay, Thermostatic, Miniature, 6 VDC, 30 Sec.	1201-003	22
L401	Choke, Audio, Iron Core, 132 h, ± 1%	1501-007	37C
L402	Choke, Audio, Iron Core, 35 h, 2430 Ohms DC, ± 10%	11853	37C
L403	Choke, Audio, Iron Core, 435 h, 2375 Ohms DC, ± 10%	11843	37C
L404	Choke, Audio, Iron Core, 350 h, 2430 Ohms DC, ± 10%	11853	37C
L405	Choke, Audio, Iron Core, 127 h, 720 Ohms DC, ± 10%	11833	37C
L1100	Choke, Swinging, Dual Winding, MIL Case, KA	11806	23
L1101	Choke, Audio, Iron Core, 3.5 h, ± 10%	11823-355	23
M100	Meter, DC, 0-2 Volts or 0-60 VA ± 2% of full scale	12300-00D	3
P100	Connector, Plug, 32 Contact	12792-032	
P101	Connector, Plug, Phenolic, 2 Contact, 15 Amp	12752-002	18
P200	Plug, Precious Metal Contacts, 10 Amps, 14 Contacts	12642-014	32
P300	Plug, Precious Metal Contacts, 10 Amps, 14 Contacts	12642-014	37C
P400	Plug, Precious Metal Contacts, 10 Amps, 14 Contacts	12642-014	37C
P500	Plug, Precious Metal Contacts, 10 Amps, 14 Contacts	12642-014	36
P700	Plug, Precious Metal Contacts, 10 Amps, 14 Contacts	12642-014	35
P1000	Connector, Plug, 750 VDC, 5 Amps, 16 Contacts	12732-016	24

LIST OF REPLACEABLE PARTS

Circuit Reference	Description	Holt Part Number	Location Figure No.
P1001	Connector, Plug, Printed Board, 10 Amps, 9 Contacts	12642-009	25
P1002	Connector, Plug, Printed Board, 7 Contacts at 45°, 5 Amps	12742-007	26
P1100	Connector, Plug, 32 Contacts, 90°	12782-032	
P1101	Plug, Molded, Line Power Cord 3 Conductors, 7 Ft., #18 AWG	12612-003	22
P1102	Connector, Plug, Phenolic, 15 Amps, 2 Contacts	12752-002	22
P1200	Connector, Plug, Precious Metal Contacts, 10 Amps, 14 Contacts	12642-014	30
P1300	Connector, Plug, Metal Contacts, 10 Amps, 14 Contacts	12642-014	29
P1400	Connector, Plug, Precious Metal Contacts, 10 Amps, 14 Contacts	12642-014	28
P1500	Connector, Plug, Precious Metal Contacts, 10 Amps, 14 Contacts	12642-014	27
Q200 & Q201	Part of Z201		
Q301	Transistor, NPN, Silicon, T1 480	11300-210	34
Q302	Transistor, PNP, Germanium, 2N~~1303~~ 158	~~11205-206~~ 0201-002	34
Q303	Transistor, NPN, Germanium, 2N1304	0201-003	34
Q401 & Q402	Transistor, PNP, Silicon, Audio, 2N327A	11301-214	37C
Q403	Transistor, NPN, Germanium, 2N~~1302~~ 209	~~11206-206~~ 0201-004	37C
Q500	Transistor, PNP, Silicon, 2N2905	0204-003	
Q1000	Transistor, PNP, Silicon, 2 Watts, .6 Amp, 2N1131	11350-210	25
Q1001	Transistor, PNP, Germanium, 40 Watts, 3 Amps, 2N554	11298-212	24
Q1200	Transistor, PNP, Germanium, 20 Watts, -40 Vcb, 3 Amps, 2N1038-1	11297-210	30
Q1201 thru Q1204	Transistor, PNP, Germanium 90 Watts, 40 V, 5 Amps, 2N1539A	11296-212	30
Q1205	Transistor, PNP, Germanium 20 MW, 40 Vcb, 200 MA, 2N1193	11204-212	30
Q1206	Transistor, NPN, Silicon, 2 Watts, 40 Vcb, T1 484	11349-210	30
R200	Resistor, Fixed, Deposited Carbon 26.7 K Ohms, 1/2 Watt, ± 1%	10003-26H	31
R201	Resistor, Fixed, Composition 180 Ohms, 1/2 Watt, ± 10%	10001-181	31
R202 *	Resistor, Fixed, Composition, 8.2 K Ohms, 1/2 Watt, ± 10%	10001-822	31

* Factory Selected, Typical Value Shown.

Circuit Reference	Description	Holt Part Number	Location Figure No.
R203	Resistor, Fixed, Composition 4.7 K Ohms, 1/2 Watt, ± 10% (Part of Z201)	10001-472	31
R204	Resistor, Fixed, Composition 1 K Ohm, 1/2 Watt, ± 10%	10001-102	31
R205	Resistor, Fixed, Composition 10 K Ohms, 1/2 Watt, ± 10%	10001-103	31
R206	Resistor, Fixed, Metal Film 221 K Ohms, 1/4 Watt, ± 1%	10104-22J	31
R207	Resistor, Fixed, Deposited Carbon 47.5 K Ohms, 1 Watt, ± 1%	10063-47D	31
R208	Resistor, Fixed, Deposited Carbon 68.1 K Ohms, 1/2 Watt, ± 1%	10003-68D	31
R209	Resistor, Fixed, Composition 3.3 K Ohms, 1/2 Watt, ± 10%	10001-332	31
R210	Resistor, Fixed, Deposited Carbon 10 M Ohms, 1/2 Watt, ± 1%	10003-106	31
R211	Resistor, Fixed, Deposited Carbon 825 K Ohms, 1/2 Watt, ± 1%	10003-82E	31
R212	Resistor, Fixed, Composition 1 K Ohm, 1/2 Watt, ± 10%	10001-102	31
R213	Resistor, Fixed, Deposited Carbon 33.2 K Ohms, 1 Watt, ± 1%	10063-33D	33
R214	Resistor, Fixed, Composition 22 K Ohms, 1 Watt, ± 10%	10031-223	31
R215	Resistor, Fixed, Composition 1.8 K Ohms, 1 Watt, ± 10%	10031-182	33
R216	Resistor, Fixed, Composition 33 K Ohms, 2 Watts, ± 10%	10021-333	31
R217	Resistor, Fixed, Deposited Carbon 47.5 K Ohms, 1 Watt, ± 1%	10063-47D	33
R218	Resistor, Fixed, Deposited Carbon 68.1 K Ohms, 1/2 Watt, ± 1%	10003-68D	33
R219	Resistor, Fixed, Deposited Carbon 562 K Ohms, 1/2 Watt, ± 1%	10003-56E	33
R220	Resistor, Fixed, Deposited Carbon 182 Ohms, 1/2 Watt, ± 1%	10003-18C	33
R221	Resistor, Fixed, Deposited Carbon 475 K Ohms, 1/2 Watt, ± 1%	10003-47E	33
R222	Resistor, Fixed, Composition 1 K Ohm, 1/2 Watt, ± 10%	10001-102	33
R223	Resistor, Fixed, Deposited Carbon 33.2 K Ohms, 1/2 Watt, ± 1%	10003-33D	33

Circuit Reference	Description	Holt Part Number	Location Figure No.
R224	Resistor, Fixed, Composition 82 K Ohms, 1/2 Watt, ± 10%	10001-823	33
R225	Resistor, Fixed, Composition 150 K Ohms, 1/2 Watt, ± 10%	10001-154	33
R226	Resistor, Fixed, Deposited Carbon 681 K Ohms, 1/2 Watt, ± 1%	10003-68E	33
R227	Resistor, Fixed, Deposited Carbon 619 K Ohms, 1/2 Watt, ± 1%	10003-61E	33
R228	Resistor, Fixed, Composition 100 Ohms, 1/2 Watt, ± 10%	10001-101	33
R229	Resistor, Fixed, Wire Wound 7.5 K Ohms, 5 Watts, ± 5%	10002-752	33
R230 *	Resistor, Fixed, Composition 5.6 K Ohms, 1/2 Watt, ± 10%	10001-562	32
R231 thru R233	Part of Z201		32
R234	Resistor, Fixed, Composition 10 K Ohms, 1/2 Watt, ± 10%	10001-103	31
R235	Resistor, Fixed, Deposited Carbon 1 M Ohm, 1/2 Watt, ± .5%	10073-105	31
R236	Resistor, Fixed, Deposited Carbon 833 K Ohms, 1/2 Watt, ± .5%	10073-00D	31
R237	Resistor, Fixed, Deposited Carbon 125 K Ohms, 1/2 Watt, ± .5%	10073-00C	31
R238	Resistor, Fixed, Deposited Carbon 100 K Ohms, 1/2 Watt, ± .5%	10073-104	31
R239	Resistor, Fixed, Deposited Carbon 10 K Ohms, 1/2 Watt, ± .5%	10073-103	31
R240	Resistor, Fixed, Deposited Carbon 12.5 K Ohms, 1/2 Watt, % .5%	10073-00A	31
R241	Resistor, Fixed, Deposited Carbon 83.3 K Ohms, 1/2 Watt, ± .5%	10073-00B	31
R242	Resistor, Fixed, Deposited Carbon 100 K Ohms, 1/2 Watt, ± .5%	10073-104	31
R243 *	Resistor, Fixed, Deposited Carbon 2.21 M Ohms, 1/2 Watt, ± 1%	10003-22L	33
R301	Resistor, Fixed, Composition 2.2 K Ohms, 1/2 Watt, ± 10%	10001-222	34
R302	Resistor, Fixed, Composition 1 K Ohm, 1/2 Watt, ± 10%	10001-102	34

* Factory Selected, Typical Value Shown.

LIST OF REPLACEABLE PARTS

Circuit Reference	Description	Holt Part Number	Location Figure No.
R303	Resistor, Fixed, Composition 10 K Ohms, 1/2 Watt, ± 10%	10001-103	34
R304 & R305	Resistor, Fixed, Composition 2.2 K Ohms, 1/2 Watt, ± 10%	10001-222	34
R306	Resistor, Variable, Wire Wound 10 K Ohms, 1/2 Watt, ± 10%	10205-103	34
R307	Resistor, Fixed, Composition 680 Ohms, 1/2 Watt, ± 10%	10001-681	34
R308	Resistor, Fixed, Composition 4.7 K Ohms, 1/2 Watt, ± 10%	10001-472	34
R309	Resistor, Fixed, Composition 4.7 K Ohms, 1/2 Watt, ± 10%	10001-472	34
R310	Resistor, Fixed, Composition 22 K Ohms, 1/2 Watt, ± 10%	10001-223	34
R311	Resistor, Fixed, Composition 56 K Ohms, 1/2 Watt, ± 10%	10001-563	34
R312	Resistor, Variable, Wire Wound 10 K Ohms, 1/2 Watt, ± 10%	10205-103	34
R401	Resistor, Fixed, Wire Wound 75 K Ohms, 1/2 Watt, ± .01%	~~10237-753~~	37A
R402	Resistor, Fixed, Deposited Carbon 1.3 M Ohm, 1/2 Watt, ± 1%	10003-135	37A
R403	Resistor, Fixed, Wire Wound 75 K Ohms, 1/2 Watt, ± .01%	~~10237-753~~	37A
R404	Resistor, Fixed, Deposited Carbon 100 K Ohms, 1/2 Watt, ± 1%	10003-104	37A
R405	Resistor, Variable, Wire Wound 200 Ohms, 2 Watts, ± 5%	~~10175-201~~	37A
R406	Resistor, Fixed, Wire Wound 10 K Ohms, 1/2 Watt, ± .01%	~~10237-103~~	37A
R407	Resistor, Fixed Deposited Carbon 100 K Ohms, 1/2 Watt, ± 1%	10003-104	37A
R408	Resistor, Fixed, Deposited Carbon 100 K Ohms, 1/2 Watt, ± 1%	10003-104	37A
R409	Resistor, Fixed, Composition 22 K Ohms, 1/2 Watt, ± 10%	10001-223	37A
R410	Resistor, Fixed, Deposited Carbon 221 K Ohms, 1/2 Watt, ± 1%	10003-22J	37A
R411	Resistor, Fixed, Deposited Carbon 1 M Ohm, 1/2 Watt, ± 1%	10003-105	37A
R412	Resistor, Fixed, Deposited Carbon 2.21 K Ohms, 1/2 Watt, ± 1%	10003-22E	37A

Circuit Reference	Description	Holt Part Number	Location Figure No.
R413	Resistor, Fixed, Deposited Carbon 1 M Ohm, 1/2 Watt, ± 1%	10003-105	37A
R414	Resistor, Fixed, Composition 1 M Ohm, 1/2 Watt, ± 10%	10001-105	37A
R415	Resistor, Fixed, Composition 220 K Ohms, 1/2 Watt, ± 10%	10001-224	37A
R416	Resistor, Fixed, Composition 1 K Ohm, 1/2 Watt, ± 10%	10001-102	37A
R417	Resistor, Fixed, Composition 1 M Ohm, 1/2 Watt, ± 10%	10001-105	37A
R418	Resistor, Fixed, Composition 220 K Ohms, 1/2 Watt, ± 10%	10001-224	37A
R419	Resistor, Fixed, Composition 3.3 K Ohms, 1/2 Watt, ± 10%	10001-332	37A
R420	Resistor, Fixed, Composition 1 M Ohm, 1/2 Watt, ± 10%	10001-105	37A
R421	Resistor, Fixed, Composition 1 K Ohm, 1/2 Watt, ± 10%	10001-102	37A
R422	Resistor, Fixed, Composition 22 K Ohms, 1/2 Watt, ± 10%	10001-223	37A
R423	Resistor, Fixed, Composition 12 K Ohms, 1/2 Watt, ± 10%	10001-123	37A
R424	Resistor, Fixed, Deposited Carbon 33.2 K Ohms, 1/2 Watt, ± 1%	10003-33D	37A
R425	Resistor, Fixed, Composition 4.7 K Ohms, 1/2 Watt, ± 10%	10001-472	37A
R426	Resistor, Fixed, Composition 2.2 K Ohms, 1/2 Watt, ± 10%	10001-222	37A
R427	Resistor, Fixed, Composition 220 Ohms, 1/2 Watt, ± 10%	10001-221	37A
R428	Resistor, Fixed, Composition 1 M Ohm, 1/2 Watt, ± 10%	10001-105	37A
R429	Resistor, Fixed, Composition 1.8 K Ohms, 1/2 Watt, ± 10%	10001-182	37A
R430	Resistor, Variable, Composition 1 M Ohm, 1/2 Watt, ± 20%	10185-105	37A
R431	Resistor, Fixed, Composition 82 K Ohms, 1/2 Watt, ± 10%	10001-823	37A
R432	Resistor, Fixed, Composition 39 K Ohms, 1/2 Watt, ± 10%	10001-393	37A
R433	Resistor, Fixed, Composition 100 K Ohms, 1/2 Watt, ± 10%	10001-104	37A

LIST OF REPLACEABLE PARTS

Circuit Reference	Description	Holt Part Number	Location Figure No.
R434	Resistor, Fixed, Composition 1.5 K Ohms, 1/2 Watt, ± 10%	10001-152	37A
R435	Resistor, Fixed, Composition 39 K Ohms, 1/2 Watt, ± 10%	10001-393	37A
R436	Resistor, Fixed, Composition 1 M Ohm, 1/2 Watt, ± 10%	10001-105	37A
R437	Resistor, Fixed, Composition 56 K Ohms, 1/2 Watt, ± 10%	10001-563	37A
R438	Resistor, Fixed, Composition 56 K Ohms, 1/2 Watt, ± 10%	10001-563	37A
R439	Resistor, Fixed, Composition 1 M Ohm, 1/2 Watt, ± 10%	10001-105	
R440	Resistor, Fixed, Composition 1 M Ohm, 1/2 Watt, ± 10%	10001-105	37A
R441	Resistor, Fixed, Composition 10 K Ohms, 1/2 Watt, ± 10%	10001-103	37A
R442	Resistor, Fixed, Composition 120 K Ohms, 1/2 Watt, ± 10%	0801-071 ~~10001-124~~	37A
R443	Resistor, Fixed, Composition 1.2 M Ohms, 1/2 Watt, ± 10%	10001-125	37A
R444	Resistor, Fixed, Composition 4.7 K Ohms, 1/2 Watt, ± 10%	10001-472	37A
R445	Resistor, Fixed, Composition 10 M Ohms, 1/2 Watt, ± 10%	10001-106	
R446	Resistor, Fixed, Composition 100 K Ohms, 1/2 Watt, ± 10%	0801-061 ~~10001-104~~	
R447	Resistor, Fixed, Composition 39 K Ohms, 1/2 Watt, ± 10%	10001-393	37A
R448	Resistor, Variable, Composition 50 Ohms, 2 Watts, ± 10%	10005-500	37A
R449	Resistor, Fixed, Composition 12 Ohms, 1/2 Watt, ± 10%	10001-120	37A
R500	Resistor, Fixed, Deposited Carbon 16.9 K Ohms, 1/2 Watt, ± 1%	10003-16C	36
R501	Resistor, Fixed, Deposited Carbon 24.9 K Ohms, 1/2 Watt, ± 1%	10003-24B	36
R502	Resistor, Fixed, Deposited Carbon 453 Ohms, 1/2 Watt, ± 1%	10003-45B	36
R503	Resistor, Fixed, Deposited Carbon 39.2 K Ohms, 1/2 Watt, ± 1%	10003-39D	36
R504	Resistor, Fixed, Deposited Carbon 4.3 K Ohms, 1/2 Watt, ± 1%	10003-43C	36

Circuit Reference	Description	Holt Part Number	Location Figure No.
R505	Resistor, Fixed, Composition 100 K Ohms, 1/2 Watt, ± 10%	10001-104	36
R506	Resistor, Fixed, Deposited Carbon 1 M Ohm, 1/2 Watt, ± 1%	10003-105	36
R507	Resistor, Fixed, Deposited Carbon 1.5 K Ohms, 1/2 Watt, ± 1%	10003-152	36
R508	Resistor, Fixed, Composition 47 K Ohms, 1/2 Watt, ± 10%	10001-473	36
R509	Resistor, Fixed, Composition 10 M Ohms, 1/2 Watt, ± 10%	10001-106	36
R510	Resistor, Fixed, Composition 10 M Ohms, 1/2 Watt, ± 10%	10001-106	36
R511	Resistor, Fixed, Deposited Carbon 47.5 K Ohms, 1/2 Watt, ± 1%	10003-47D	36
R512	Resistor, Fixed, Deposited Carbon 1 M Ohm, 1/2 Watt, ± 1%	10003-105	36
R513	Resistor, Fixed, Deposited Carbon 3.92 K Ohms, 1/2 Watt, ± 1%	10003-39C	36
R514	Resistor, Variable, Composition 10 K Ohms, 2 Watts, ± 10%	10005-103	36
R515	Resistor, Fixed, Composition 8.2 K Ohms, 1/2 Watt, ± 10%	10001-822	36
R516	Resistor, Fixed, Composition 10 K Ohms, 1 Watt, ± 10%	10031-103	36
R517	Resistor, Fixed, Composition 1 M Ohm, 1/2 Watt, ± 10%	10001-105	36
R518	Resistor, Fixed, Composition 1 M Ohm, 1/2 Watt, ± 10%	10001-105	36
R519	Resistor, Fixed, Composition 330 Ohms, 1 Watt, ± 10%	10031-331	36
R520	Resistor, Fixed, Composition 27 K Ohms, 1 Watt, ± 10%	10031-273	36
R521	Resistor, Fixed, Composition 27 K Ohms, 1 Watt, ± 10%	10031-273	36
R522 thru R525	Resistor, Fixed, Composition 820 K Ohms, 1/2 Watt, ± 10%	10001-824	36
R526 & R527	Resistor, Fixed, Composition 100 K Ohms, 1/2 Watt, ± 10%	10001-104	36
R528	Resistor, Fixed, Composition 680 Ohms, 1 Watt, ± 10%	10031-681	36

LIST OF REPLACEABLE PARTS

Circuit Reference	Description	Holt Part Number	Location Figure No.
R529 & R530	Resistor, Fixed, Composition 1.8 K Ohms, 1/2 Watt, ± 10%	10001-182	36
R531 & R532	Resistor, Fixed, Wire Wound 30 K Ohms, 10 Watts, ± 5%	10012-303	36
R534 & R535	Resistor, Fixed, Composition 1 M Ohm, 1/2 Watt, ± 10%	10001-105	36
R537 & R538	Resistor, Fixed, Composition 100 K Ohms, 2 Watts, ± 10%	10021-104	36
R539 & R540	Resistor, Fixed, Composition 220 K Ohms, 1/2 Watt, ± 10%	10001-224	19
R541 & R542	Resistor, Fixed, Composition 220 Ohms, 1 Watt, ± 10%	10031-221	19
R543	Resistor, Fixed, Wire Wound 100 Ohms, 5 Watts, ± 5%	10002-101	
R544	Resistor, Fixed, Wire Wound 100 Ohms, 5 Watts, ± 5%	10002-101	
R545	Resistor, Fixed, Composition 15 K Ohms, 1/2 Watt, ± 10%	10001-153	
R546	Resistor, Fixed, Composition 47 K Ohms, 1/2 Watt, ± 10%	10001-473	
R547	Resistor, Fixed, Composition 15 K Ohms, 1/2 Watt, ± 10%	10001-153	
R548	Resistor, Fixed, Composition 10 K Ohms, 1/2 Watt, ± 10%	10001-103	
R549	Resistor, Fixed, Composition 47 K Ohms, 1/2 Watt, ± 10%	10001-473	
R550	Resistor, Fixed, Composition 2.2 K Ohms, 1/2 Watt, ± 10%	10001-222	
R551	Resistor, Fixed, Deposited Carbon 47.5 K Ohms, 1/2 Watt, ± 1%	10003-47D	
R552	Resistor, Fixed, Deposited Carbon 30.1 K Ohms, 1/2 Watt, ± 1%	10003-30G	
R553	Resistor, Fixed, Deposited Carbon 825 K Ohms, 1/2 Watt, ± 1%	10003-82E	
R554	Resistor, Variable, Composition 50 K Ohms, 1/2 Watt, ± 20%	10185-503	
R600 thru R607	Resistor, Fixed, Wire Wound 20 K Ohms, ± .01%	10237-203	20
R608	Resistor, Fixed, Wire Wound 19.8 K Ohms, ± .01%	10237-19A	20

LIST OF REPLACEABLE PARTS

Circuit Reference	Description	Holt Part Number	Location Figure No.
R609 thru R616	Resistor, Fixed, Wire Wound 2 K Ohms, ± .01%	10237-202	20
R617	Resistor, Fixed, Wire Wound 1.8 K Ohms, ± .01%	10237-182	20
R618 thru R627	Resistor, Fixed, Wire Wound 200 Ohms, ± .01%	10237-201	20
R628 thru R636	Resistor, Fixed, Wire Wound 20 Ohms, ± .01%	10227-200	20
R637 thru R645	Resistor, Fixed, Wire Wound 2 Ohms, ± .01%	10227-020	20
R646	Resistor, Variable, Wire Wound 100 Ohms, 3.5 Watts, ± 1%	0806-032	20
R647	Resistor, Fixed, Deposited Carbon 1 K Ohm, 1/2 Watt, ± 1%	10003-102	20
R648 thru R652	Resistor, Fixed, Composition 1.8 K Ohms, 1/2 Watt, ± 10%	10001-182	20
R653 & R654	Resistor, Fixed, Composition 1 K Ohm, 1/2 Watt, ± 10%	10001-102	20
R655 thru R657	Resistor, Fixed, Composition 1.8 K Ohms, 1/2 Watt, ± 10%	10001-182	20
R658 & R659	Resistor, Fixed, Composition 6.8 K Ohms, 1/2 Watt, ± 10%	10001-682	20
R660	Resistor, Fixed, Composition 18 K Ohms, 1/2 Watt, ± 10%	10001-183	20
R661	Resistor, Fixed, Deposited Carbon 1.5 K Ohms, 1/2 Watt, ± 1%	10003-152	20
R662	Resistor, Fixed, Wire Wound ~~70~~ Ohms, ~~1/4~~ Watt, ± ~~1~~%	0802-~~162~~	
R663	Resistor, Fixed, Wire Wound 100 Ohms, 1/2 Watt, ± .01%	0802-150	
R700	Resistor, Fixed, Wire Wound 178.5 Ohms, ± .01%	0802-~~015~~	35
R701	Resistor, Fixed, Wire Wound 10 Ohms, 1/3 Watt, ± 1%	10037-100	35
R702	Resistor, Fixed, Deposited Carbon 100 K Ohms, 1/2 Watt, ± 1%	10003-104	35
R703	Resistor, Fixed, Wire Wound 10 K Ohms, ± .01%	~~10237-103~~	35

LIST OF REPLACEABLE PARTS

Circuit Reference	Description	Holt Part Number	Location Figure No.
R704	Resistor, Variable, Slide Wire 10 Ohms, 1/4 Watt, ± 10%	10165-100	35
R705	Resistor, Fixed, Wire Wound 10 K Ohms, ± .01%	0842-210 ~~10237-103~~	35
R706	Resistor, Fixed, Deposited Carbon 619 K Ohms, 1/2 Watt, ± 1%	10003-61E	35
R707	Resistor, Fixed, Deposited Carbon 221 K Ohms, 1/2 Watt, ± 1%	10003-22J	35
R708	Resistor, Fixed, Deposited Carbon 162 K Ohms, 1/2 Watt, ± 1%	10003-16N	35
R709	Resistor, Fixed, Deposited Carbon 10 K Ohms, 1/2 Watt, ± 1%	10003-103	35
R710	Resistor, Fixed, Deposited Carbon 4.32 M Ohms, 1/2 Watt, ± 1%	10003-43F	35
R711	Resistor, Fixed, Deposited Carbon 619 Ohms, 1/2 Watt, ± 1%	10003-61B	35
R712	Resistor, Fixed, Deposited Carbon 511 Ohms, 1/2 Watt, ± 1%	10003-51B	35
R713	Resistor, Fixed, Deposited Carbon 10 K Ohms, 1 Watt, ± 1%	10063-103	35
R714	Resistor, Fixed, Deposited Carbon 100 K Ohms, 1/2 Watt, ± 1%	10003-104	35
R715	Resistor, Fixed, Deposited Carbon 150 K Ohms, 1/2 Watt, ± 1%	10003-154	35
R716	Resistor, Fixed, Deposited Carbon 10 K Ohms, 1 Watt, ± 1%	10063-103	35
R717	Resistor, Fixed, Deposited Carbon 332 Ohms, 1/2 Watt, ± 1%	10003-33B	35
R718	Resistor, Fixed, Deposited Carbon 100 K Ohms, 1/2 Watt, ± 1%	10003-104	35
R719	Resistor, Fixed, Deposited Carbon 162 K Ohms, 1/2 Watt, ± 1%	10003-16N	35
R720 *	Resistor, Fixed, ~~Deposited Carbon~~ METAL FILM ~~1.5~~ K Ohms, 1/2 Watt, ± 1% R.C6	0804-072 ~~10003-152~~	35
R721	Resistor, Variable, Wire Wound ~~200~~ 1K Ohms, 10 Turn, ± 5%	0806-048 ~~10175-201~~	35
R722	Resistor, Fixed, Composition 330 Ohms, 1/2 Watt, ± 10%	10001-331	35
R723	Resistor, Fixed, Deposited Carbon 1.18 K Ohms, 1/2 Watt, ± 1%	10003-11J	35

* Factory Selected, Typical Value Shown.

LIST OF REPLACEABLE PARTS

Circuit Reference	Description	Holt Part Number	Location Figure No.
R724	Resistor, Fixed, Wire Wound 10 K Ohms, 5 Watts, ± 5%	10002-103	35
R725	Resistor, Fixed, Deposited Carbon 1 K Ohm, 1/2 Watt, ± 1%	10003-102	35
R726	Resistor, Fixed, Deposited Carbon 130 K Ohms, 1/2 Watt, ± 1%	10003-134	35
R727	Resistor, Fixed, Wire Wound 10 K Ohms, ± .01%	~~10237-103~~	35
R728	Resistor, Fixed, Wire Wound 445 Ohms, ± .01%	0802-~~049~~	35
R729	Resistor, Fixed, Wire Wound 10 K Ohms, ± .01%	~~10237-103~~	35
R1000	Resistor, Fixed, Composition 10 Ohms, 1/2 Watt, ± 10%	10001-100	25
R1001	Resistor, Fixed, Composition 10 Ohms, 1/2 Watt, ± 10%	10001-100	25
R1002	Resistor, Fixed, Composition 390 Ohms, 1 Watt, ± 10%	10031-391	25
R1003	Resistor, Fixed, Deposited Carbon 249 Ohms, 1/2 Watt, ± 1%	10003-24D	25
R1004	Resistor, Fixed, Composition 4.7 K Ohms, 2 Watts, ± 10%	10021-472	25
R1005	Resistor, Fixed, Wire Wound 2.5 K Ohms, 1/4 Watt, ± 1%	10267-252	26
R1006 *	Resistor, Fixed, Wire Wound 3.7 K Ohms, 1/4 Watt, ± 1%	10267-372	26
R1007 *	Resistor, Fixed, Wire Wound 50 Ohms, 1/4 Watt, ± 1%	10267-500	26
R1008	Resistor, Fixed, Wire Wound 5 K Ohms, 1/4 Watt, ± 1%	10267-502	26
R1009	Resistor, Variable, Slide Wire 15 Ohms, 1/4 Watt, ± 10%	10165-150	26
R1010	Resistor, Fixed, Wire Wound 10 K Ohms, 1/4 Watt, ± .05%	10217-103	26
R1011	Resistor, Variable, Slide Wire 15 Ohms, 1/4 Watt, ± 10%	10165-150	26
R1012	Resistor, Fixed, Wire Wound 30 Ohms, 1/4 Watt, ± .05%	10217-300	26
R1013	Resistor, Fixed, Wire Wound 1 Ohm, 5 Watts, ± 5%	10002-010	24

* Factory Selected, Typical Value Shown.

LIST OF REPLACEABLE PARTS

Circuit Reference	Description	Holt Part Number	Location Figure No.
R1014	Resistor, Fixed, Composition 91 Ohms, 1/2 Watt, ± 10%	10001-910	25
R1015	Resistor, Fixed, Composition 180 Ohms, 1 Watt, ± 10%	10031-181	24
R1100	Resistor, Fixed, Wire Wound 2.5 K Ohms, 10 Watts, ± 5%	10012-252	22
R1102	Resistor, Fixed, Wire Wound 5 Ohms, 10 Watts, ± 5%	10012-050	22
R1103	Resistor, Fixed, Wire Wound 10 Ohms, 20 Watts, ± 5%	10042-100	22
R1200	Resistor, Fixed, Composition 82 Ohms, 1/2 Watt, ± 10%	10001-820	30
R1201	Resistor, Fixed, Composition 470 Ohms, 1/2 Watt, ± 10%	10001-471	30
R1202	Resistor, Fixed, Composition 1.5 K Ohms, 1/2 Watt, ± 10%	10001-152	30
R1203 thru R1206	Resistor, Fixed, Wire Wound .5 Ohm, 5 Watts, ± 1%	10057-05A	30
R1207	Resistor, Fixed, Composition 56 Ohms, 1/2 Watt, ± 10%	0801-025 ~~10001-560~~	30
R1300	Resistor, Fixed, Composition 1 K Ohm, 1/2 Watt, ± 10%	10001-102	29
R1301 & R1302	Resistor, Fixed, Composition 27 Ohms, 2 Watts, ± 10%	10021-270	29
R1303	Resistor, Fixed, Composition 1 K Ohm, 1/2 Watt, ± 10%	10001-102	29
R1304	Resistor, Fixed, Wire Wound 20 K Ohms, 5 Watts, ± 10%	10002-203	29
R1305	Resistor, Fixed, Composition 68 K Ohms, 2 Watts, ± 10%	10021-683	29
R1306	Resistor, Fixed, Composition 47 K Ohms, 1/2 Watt, ± 10%	10001-473	29
R1307	Resistor, Fixed, Deposited Carbon 150 K Ohms, 1/2 Watt, ± 1%	10003-154	29
R1308	Resistor, Fixed, Deposited Carbon 475 K Ohms, 1 Watt, ± 1%	0803-154	29
R1400	Resistor, Fixed, Composition 470 K Ohms, 1/2 Watt, ± 10%	10001-474	28
R1401	Resistor, Fixed, Composition 220 K Ohms, 1/2 Watt, ± 10%	10001-224	28

Circuit Reference	Description	Holt Part Number	Location Figure No.
R1402	Resistor, Fixed, Composition 1 K Ohm, 1/2 Watt, ± 10%	10001-102	28
R1403	Resistor, Fixed, Composition 150 K Ohms, 1/2 Watt, ± 10%	10001-154	28
R1404	Resistor, Fixed, Composition 1 M Ohm, 1/2 Watt, ± 10%	10001-105	28
R1405	Resistor, Fixed, Deposited Carbon 200 K Ohms, 1/2 Watt, ± 1%	10003-204	28
R1406	Resistor, Fixed, Deposited Carbon 324 K Ohms, 1/2 Watt, ± 1%	10003-32E	28
R1407	Resistor, Fixed, Composition 270 K Ohms, 1/2 Watt, ± 10%	10001-274	28
R1408	Resistor, Fixed, Composition 100 K Ohms, 1/2 Watt, ± 10%	10001-104	28
R1409	Resistor, Fixed, Composition 150 K Ohms, 1/2 Watt, ± 10%	10001-154	28
R1410	Resistor, Fixed, Composition 100 K Ohms, 1/2 Watt, ± 10%	10001-104	28
R1411	Resistor, Fixed, Composition 470 K Ohms, 1/2 Watt, ± 10%	10001-474	28
R1412	Resistor, Fixed, Composition 1 K Ohm, 1/2 Watt, ± 10%	10001-102	28
R1413	Resistor, Fixed, Composition 100 K Ohms, 1/2 Watt, ± 10%	10001-104	28
R1414	Resistor, Fixed, Composition 1 M Ohm, 1/2 Watt, ± 10%	10001-105	28
R1415	Resistor, Fixed, Deposited Carbon 68.1 K Ohms, 1/2 Watt, ± 1%	10003-68D	28
R1416	Resistor, Fixed, Deposited Carbon 249 K Ohms, 1/2 Watt, ± 1%	10003-24K	28
R1417	Resistor, Fixed, Composition 4.7 K Ohms, 1/2 Watt, ± 10%	10001-473	
R1500	Resistor, Fixed, Composition 330 K Ohms, 1/2 Watt, ± 10%	10001-334	27
R1501	Resistor, Fixed, Wire Wound 15 K Ohms, 5 Watts, ± 5%	10002-153	27
R1502	Resistor, Fixed, Composition 1.5 K Ohms, 1/2 Watt, ± 10%	10001-152	27
R1503	Resistor, Fixed, Deposited Carbon 2 M Ohms, 1/2 Watt, ± 1%	10003-205	27
R1504	Resistor, Fixed Deposited Carbon 3.32 M Ohms, 1/2 Watt, ± 1%	10003-33F	27

Circuit Reference	Description	Holt Part Number	Location Figure No.
R1505	Resistor, Fixed, Deposited Carbon 88.7 K Ohms, 1/2 Watt, ± 1%	10003-88C	27
R1506	Resistor, Fixed, Deposited Carbon 68.1 K Ohms, 1/2 Watt, ± 1%	10003-68D	27
R1507	Resistor, Fixed, Composition 100 K Ohms, 1/2 Watt, ± 10%	10001-104	27
R1508	Resistor, Fixed, Deposited Carbon 475 K Ohms, 1/2 Watt, ± 1%	10003-47E	27
R1509	Resistor, Fixed, Composition 100 K Ohms, 1/2 Watt, ± 10%	10001-104	27
R1510	Resistor, Fixed, Composition 1 K Ohm, 1/2 Watt, ± 10%	10001-102	27
R1511	Resistor, Fixed, Composition 100 K Ohms, 1/2 Watt, ± 10%	10001-104	27
R1512	Resistor, Fixed, Deposited Carbon 25.5 K Ohms, 1/2 Watt, ± 1%	10003-25D	27
R1513	Resistor, Fixed, Composition 470 K Ohms, 1/2 Watt, ± 10%	10001-474	27
R1514	Resistor, Fixed, Deposited Carbon 287 K Ohms, 1/2 Watt, ± 1%	10003-28E	27
R1515	Resistor, Fixed, Deposited Carbon 221 K Ohms, 1/2 Watt, ± 1%	10003-22J	27
RT200	Part of Z200		
RT201	Part of Z200		
S100	Switch, Bat Handle, Toggle SPST, 3 Amp, 250 Volts	12004-101	3
S101	Switch, Bat Handle, Toggle DPDT, 3 Amp, 250 Volts	12014-202	3
S102	Switch, Button, Non-Locking SPDT, 3 Amp, 120 Volts	12025-102	3
S103	Switch, Range	52716	3
S200	Switch, Rotary, 7 Position, 5 Section	12011	32
S201	Switch, Rotary, 11 Position, 4 Section	12021	32
S600	Switch, 100 Volt	12091	20, 3
S601	Switch, 10 Volt	12101	3
S602	Switch, 1 Volt	12051	3
S603	Switch, 100 MV	12061	3
S604	Switch, 10 MV	12071	20, 3

LIST OF REPLACEABLE PARTS

Circuit Reference	Description	Holt Part Number	Location Figure No.	
S1200	Switch, Thermal, SPST	12027-101	30	
T100	Transformer, Output	52298 731A	19	
T101	Transformer, Current	52703	19	
T102	Transformer, Output, Low Frequency	52182	18	
T600	Transformer, High Voltage, High Frequency	52345	20	
T601	Transformer, Ratio	11630	20	
T1000	Transformer, Power	11632	24	
T1100	Transformer, Plate	11672	23	
T1101	Transformer, Filament	11671	23	
TB1100	Terminal Strip, Barrier Type, Bakelite, 5 Contact	12608-005	23	
TB1101	Terminal Strip, Barrier Type, Bakelite, 10 Contact	12628-010	22	
V200 **	Tube, Electron, 12AX7	11005	32	2.10
V201	Tube, Electron, 7199	11009	32	1.70
V202 **	Tube, Electron, 12AX7	11005	32	2.10
V203 **	Tube, Electron, 6DK6	11003	32	1.90
V204	Tube, Electron, 6AQ5	11013	32	1.20
V401	Tube, Electron, 6267	11017	37C	2.30
V402	Tube, Electron, 12AX7	11005	37C	2.10
V403	Tube, Electron, 12AT7	11025	37C	2.40
V404	Tube, Electron, 7199	11009	37C	1.70
V501 **	Tube, Electron, 7199	11009	36	1.70
V502	Tube, Electron, 7199	11009	36	1.70
V503	Tube, Electron, 12AU7	11007	36	2.00
V504 ***	Tube, Electron, 12BH7	11019	36	7.20
V505	Tube, Electron, 12AX7	11005	36	2.10
V506 & *** V507 ***	Tube, Electron, 6550	11040	19	7.50
V701 **	Tube, Electron, 6DK6	11003	35	1.90
V702 & V703	Tube, Electron, 6DK6	11003	35	1.90

** Factory Selected for Minimum Microphonics and Noise.

*** Factory Selected for Balance and Minimum Distortion.

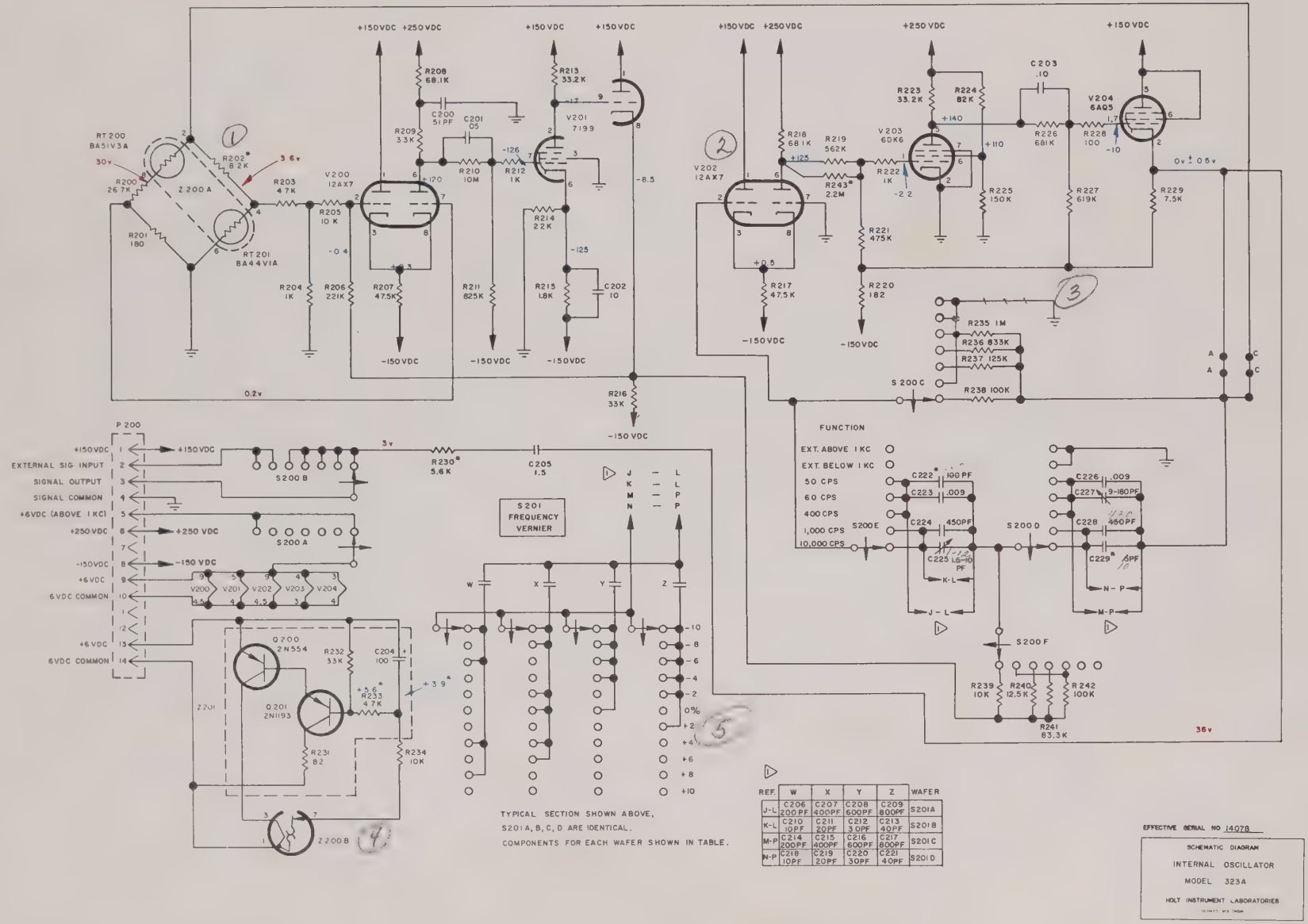
LIST OF REPLACEABLE PARTS

Circuit Reference	Description	Holt Part Number	Location Figure No.	
V704	Tube, Electron, 5687	11018	35	5.30
V1300	Tube, Electron, 6336A	11060	29	42.00
V1301	Tube, Electron, 6DK6	11003	29	1.90
V1302	Tube, Electron, 12AU7	11007	29	2.00
V1400	Tube, Electron, 6DK6	11003	28	1.90
V1401	Tube, Electron, 12AX7	11005	28	2.10
V1402	Tube, Electron, 6080	11050	28	7.05
V1403	Tube, Electron, 12AX7	11005	28	2.10
V1404	Tube, Electron, 6DK6	11003	28	1.90
V1500	Tube, Electron, 6AR6	11030	27	11.40
V1501	Tube, Electron, 6DK6	11003	27	1.90
V1502	Tube, Electron, 12AX7	11005	27	2.10
V1503	Tube, Electron, 5651	11023	27	2.30
V1504	Tube, Electron, 6DK6	11003	27	1.90
Z200	Thermistor Oven Assembly (Temp. 55° C., 6.3 VDC) consisting of:	82375 13155-055	32	
	Thermistor, RT200, BA51V3, 100K Ohms, ± 20%	13118A	32	
	Thermistor, RT201, BA44V1, 40K Ohms, ± 20%	13108A	32	
Z201	Oven Heater Switch Assembly Consisting of:	82356	32	
	Capacitor, C204, Electrolytic 100 MFD, 12 VDC, -10% +150%	10671-107		
	Transistor, Q200, 2N554	11298-212		
	Transistor, Q201, 2N1193	11204-212		
	Resistor, R231, Fixed, Composition 82 Ohms, 1/2 Watt, ± 10%	10001-820		
	Resistor, R232, Fixed, Composition 33K Ohms, 1/2 Watt, ± 10%	10001-333		
	Resistor, R233, Fixed, Composition 4.7 K Ohms, 1/2 Watt, ± 10%	10001-472		
Z401	Recovery Module	52702	37C	
Z1000	Reference Voltage Oven Assembly Consisting of:		24	
	Oven, Temp. 60° C., 6.3 VDC	*		
	Diode, Zener, CR1004, Specially Selected	*		

* To replace a defective component in Z1000, the reference pack must be returned to the factory.

*FACTORY SELECTED VALUE, TYPICAL VALUE INDICATED.
ALL RESISTOR VALUES IN OHMS
ALL CAPACITOR VALUES IN MICROFARADS
UNLESS OTHERWISE SPECIFIED.

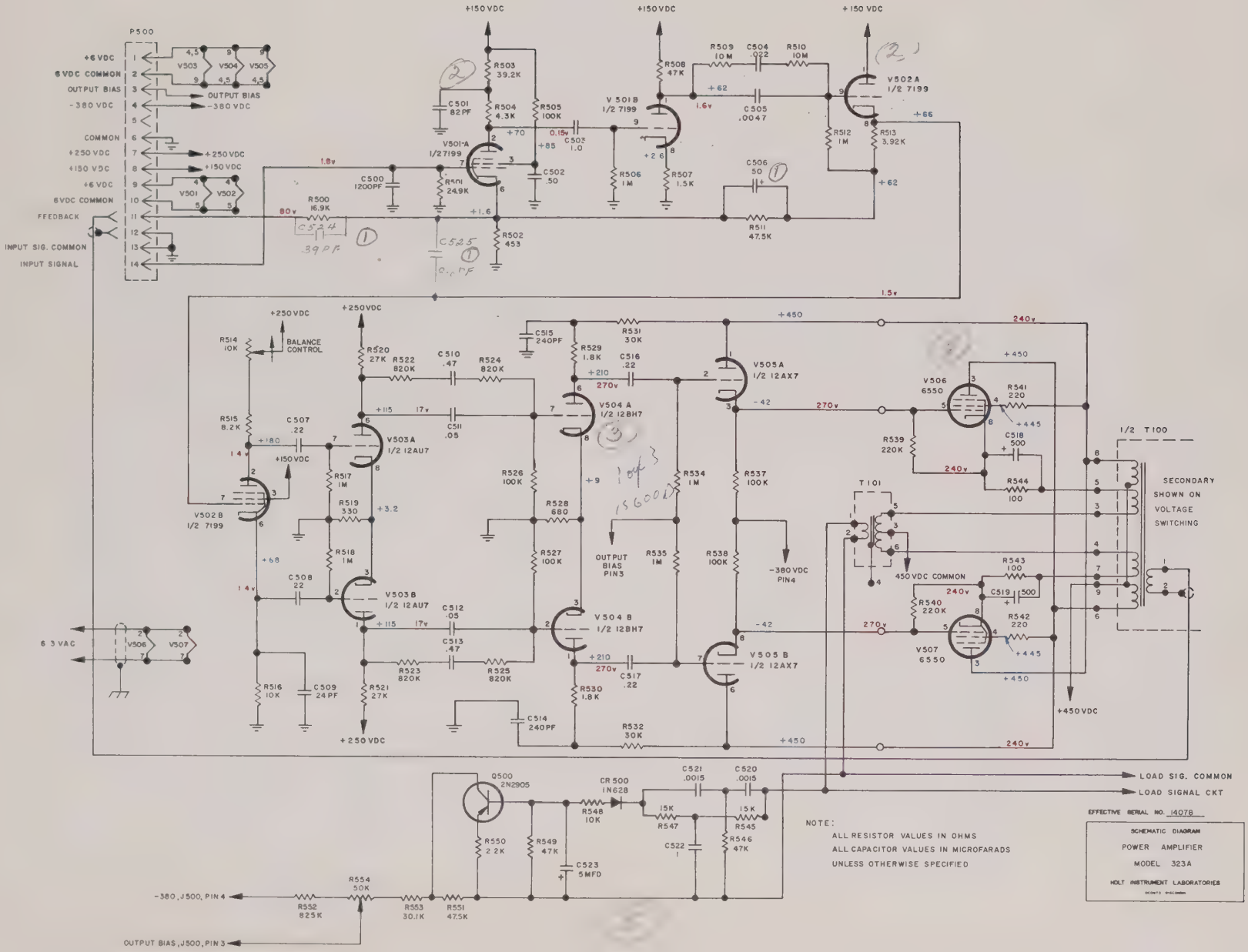
● OVEN HEATER "ON"



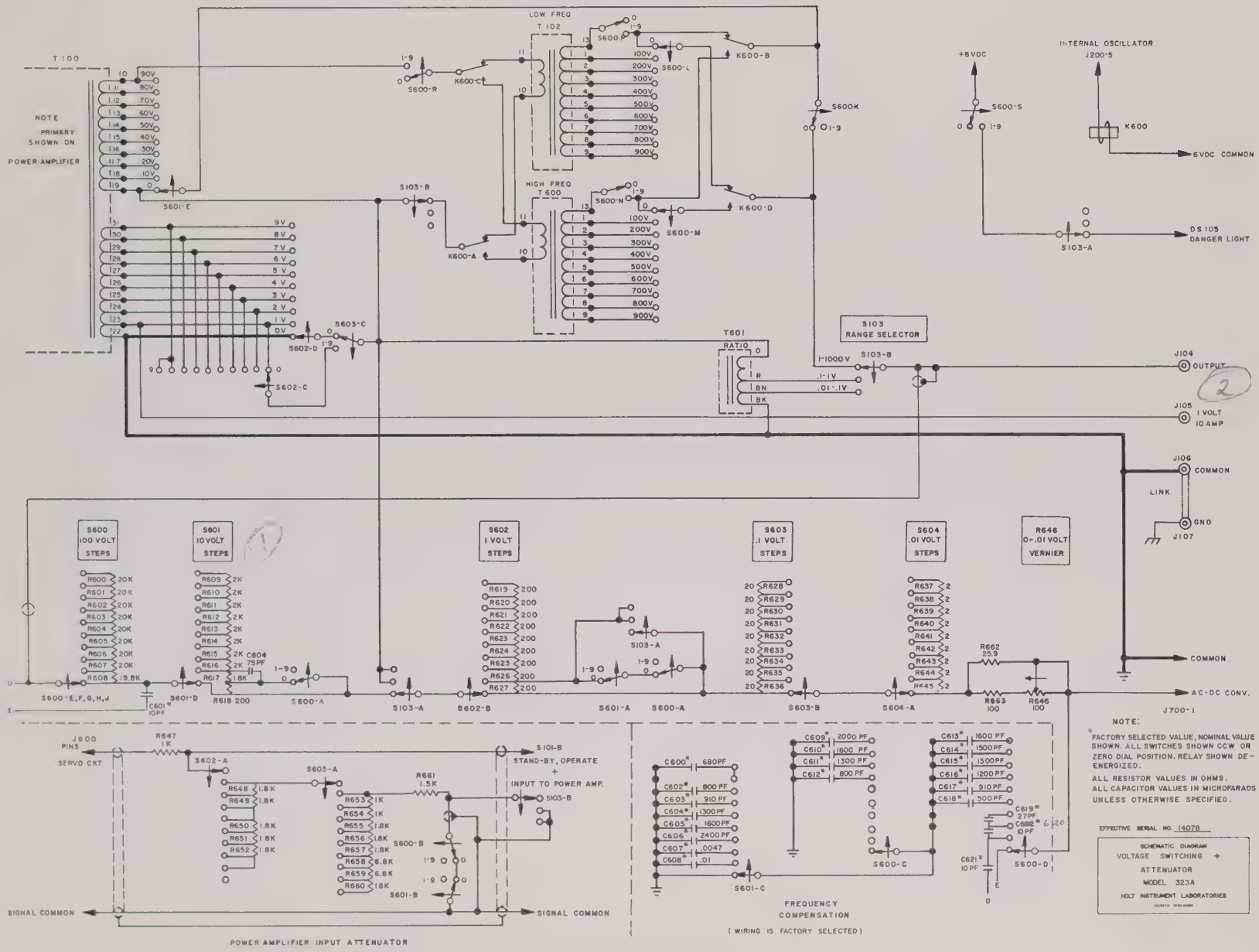
REF.	W	X	Y	Z	WAFER
J-L	C206 200 PF	C207 400PF	C208 600PF	C209 800PF	S201A
K-L	C210 10PF	C211 20PF	C212 30PF	C213 40PF	S201B
M-P	C214 200PF	C215 400PF	C216 600PF	C217 800PF	S201C
N-P	C218 10PF	C219 20PF	C220 30PF	C221 40PF	S201D

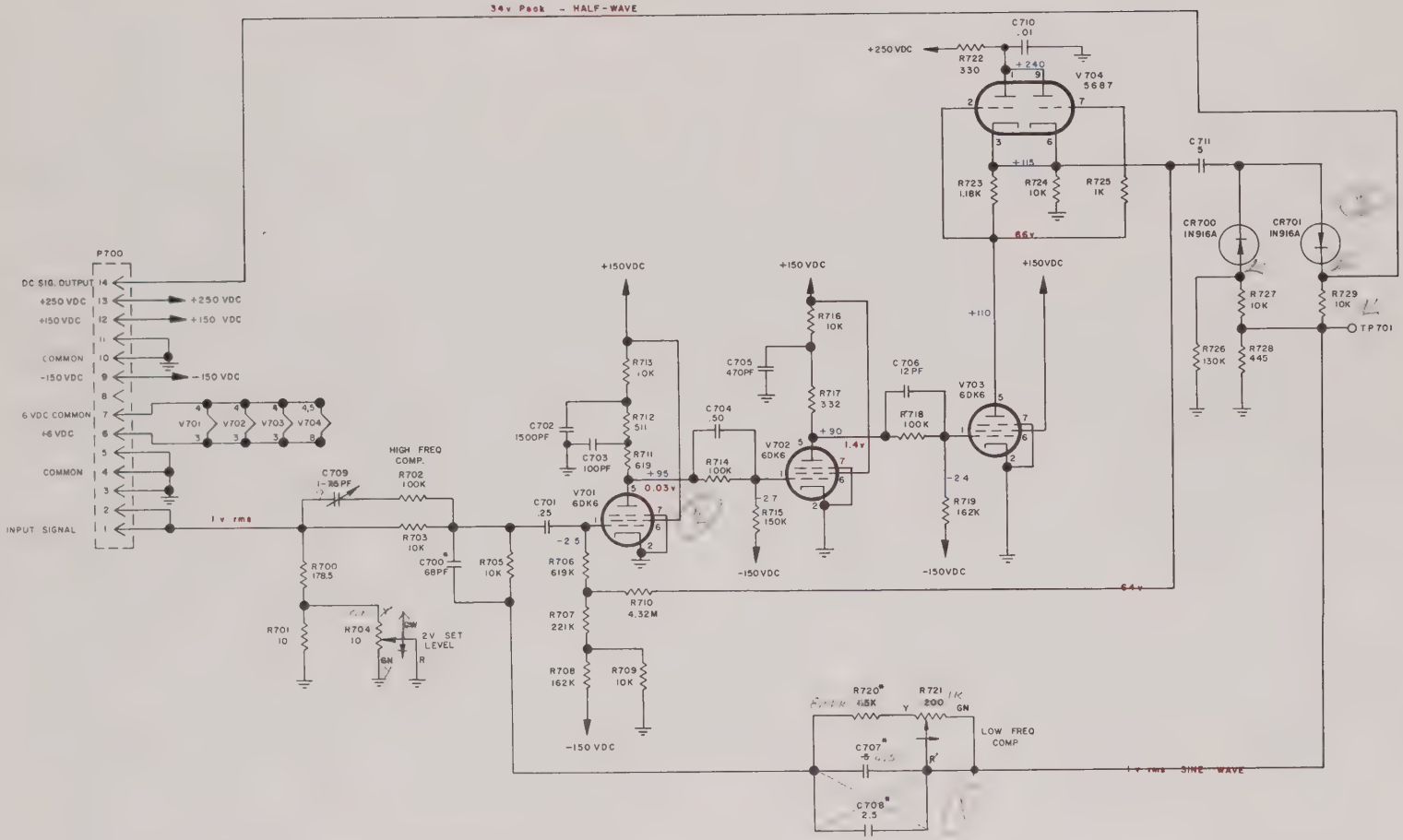
EFFECTIVE SERIAL NO 14078

SCHEMATIC DIAGRAM
INTERNAL OSCILLATOR
MODEL 323A
HOLT INSTRUMENT LABORATORIES


P500
+6 VDC
6 VDC COMMON
OUTPUT BIAS
-380 VDC
COMMON
+250 VDC
+150 VDC
+6 VDC
6 VDC COMMON
FEEDBACK
INPUT SIG. COMMON
INPUT SIGNAL
V503
V504
V505
V501
V502
OUTPUT BIAS
-380 VDC
+150 VDC
+150 VDC
+150 VDC
R503 39.2K
R504 4.3K
R505 100K
C501 82PF
V501-A 1/2 7199
R501 24.9K
C500 1200PF
C502 .50
C503 1.0
R500 16.9K
C524 .39PF
C525 .01MF
R502 453
V501-B 1/2 7199
R508 47K
R509 10M
C504 .022
R510 10M
C505 .0047
R506 1M
R507 1.5K
C506 50
R511 47.5K
V502A 1/2 7199
R512 1M
R513 3.92K
+250VDC
+250VDC
BALANCE CONTROL
R514 10K
R515 8.2K
R520 27K
R522 820K
C510 .47
R524 820K
C507 .22
C511 .05
V503A 1/2 12AU7
R517 1M
R519 330
V502B 1/2 7199
R518 1M
C508 22
V503B 1/2 12AU7
C512 .05
C513 .47
R523 820K
R525 820K
R516 10K
C509 24PF
R521 27K
+250 VDC
C514 240PF
C515 240PF
R529 1.8K
C516 .22
V504A 1/2 12BH7
R526 100K
R528 680
R527 100K
V504B 1/2 12BH7
C517 .22
R530 1.8K
R531 30K
R532 30K
R534 1M
R535 1M
R537 100K
R538 100K
OUTPUT BIAS PIN3
-380 VDC PIN4
V505A 1/2 12AX7
V505B 1/2 12AX7
+450
+450
+450
+450
+450VDC
V506 6550
V507 6550
R539 220K
R541 220
R542 220
R540 220K
C518 500
C519 500
R544 100
R543 100
450 VDC COMMON
T101
1/2 T100
SECONDARY SHOWN ON VOLTAGE SWITCHING
6.3 VAC
V506
V507
Q500 2N2905
CR 500 1N628
R548 10K
R550 2.2K
R549 47K
C523 5MFD
C521 .0015
C520 .0015
R547 15K
R545 15K
C522
R546 47K
R554 50K
R552 825K
R553 30.1K
R551 47.5K
-380, J500, PIN 4
OUTPUT BIAS, J500, PIN 3
LOAD SIG. COMMON
LOAD SIGNAL CKT
NOTE:
ALL RESISTOR VALUES IN OHMS
ALL CAPACITOR VALUES IN MICROFARADS
UNLESS OTHERWISE SPECIFIED
EFFECTIVE SERIAL NO. 14078
SCHEMATIC DIAGRAM
POWER AMPLIFIER
MODEL 323A
HOLT INSTRUMENT LABORATORIES

Sweet Peas


T100
NOTE
PRIMARY
SHOWN ON
POWER AMPLIFIER
S601-E
LOW FREQ
T 102
HIGH FREQ
T 600
S600-R
S600-N
S600-L
S600-M
S600-K
K600-B
K600-C
K600-D
K600-A
S103-B
INTERNAL OSCILLATOR
J200-5
+6VDC
S600-S
K600
6VDC COMMON
DS 105
DANGER LIGHT
S103-A
S603-C
S602-D
S602-C
T601
RATIO
S103
RANGE SELECTOR
1-1000 V
.1-1V
.01-.1V
J104
OUTPUT
J105
1 VOLT
10 AMP
J106
COMMON
LINK
GND
J107
S600
100 VOLT
STEPS
S601
10 VOLT
STEPS
S602
1 VOLT
STEPS
S603
.1 VOLT
STEPS
S604
.01 VOLT
STEPS
R646
0-.01 VOLT
VERNIER
S600-E,F,G,H,J
S601-D
S600-A
S103-A
S602-B
S601-A
S603-B
S604-A
R662
25.9
R663
100
R646
100
COMMON
AC-DC CONV.
J700-1
J800
PINS
SERVO CKT
R647
1K
S602-A
S603-A
R661
1.5K
S101-B
STAND-BY, OPERATE
+
INPUT TO POWER AMP.
S103-B
S600-B
S601-B
SIGNAL COMMON
SIGNAL COMMON
POWER AMPLIFIER INPUT ATTENUATOR
S601-C
S600-C
S600-D
FREQUENCY
COMPENSATION
(WIRING IS FACTORY SELECTED)
NOTE:
* FACTORY SELECTED VALUE, NOMINAL VALUE SHOWN. ALL SWITCHES SHOWN CCW OR ZERO DIAL POSITION. RELAY SHOWN DE-ENERGIZED.
ALL RESISTOR VALUES IN OHMS.
ALL CAPACITOR VALUES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
EFFECTIVE SERIAL NO. 14078
SCHEMATIC DIAGRAM
VOLTAGE SWITCHING + ATTENUATOR
MODEL 323A
HOLT INSTRUMENT LABORATORIES



NOTE

*FACTORY SELECTED VALUE, OPTIMUM VALUE SHOWN

ALL CAPACITOR VALUES IN MICROFARADS

ALL RESISTOR VALUES IN OHMS

UNLESS OTHERWISE SPECIFIED

EFFECTIVE SERIAL NO. 14078

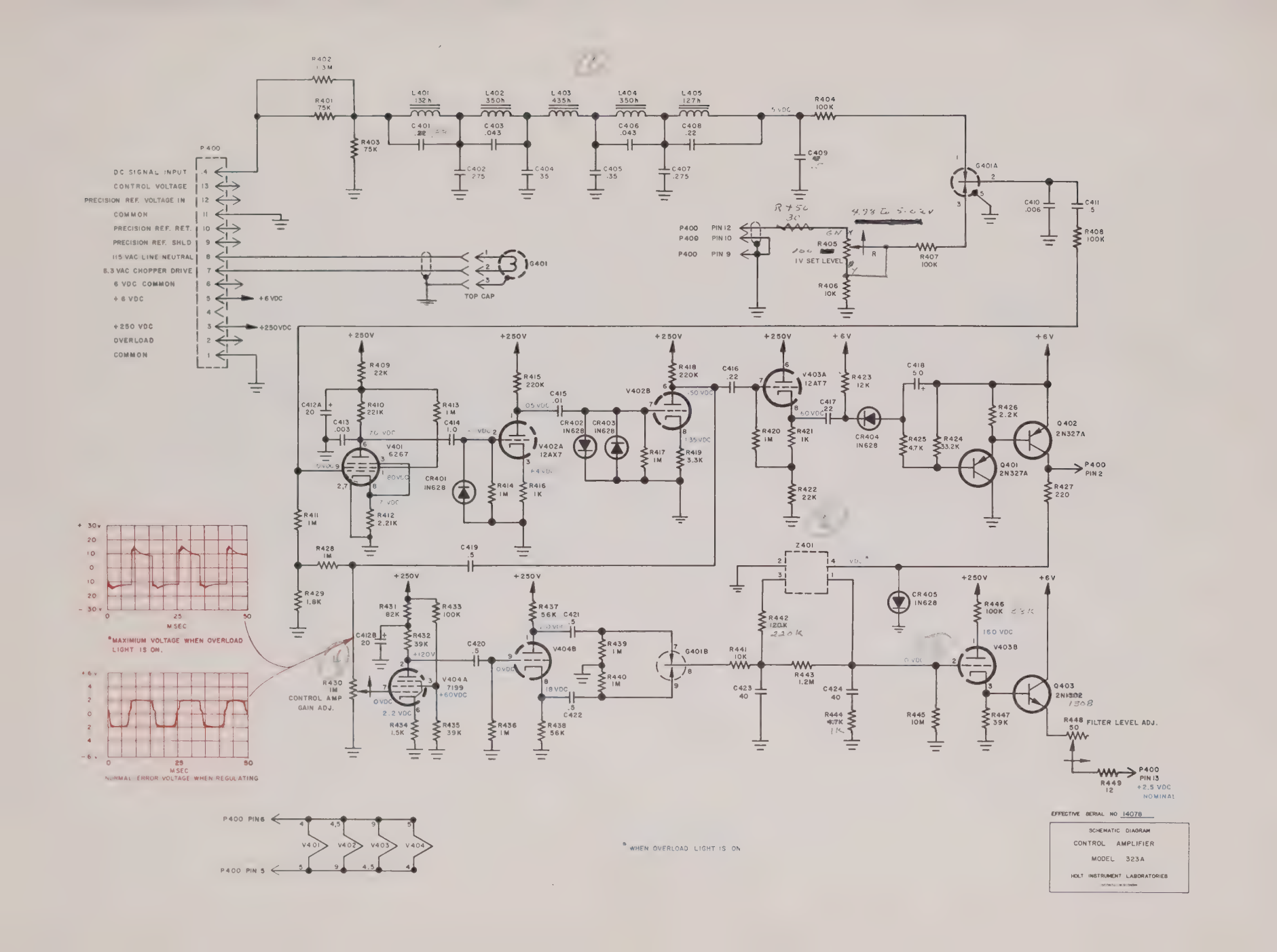
SCHEMATIC DIAGRAM

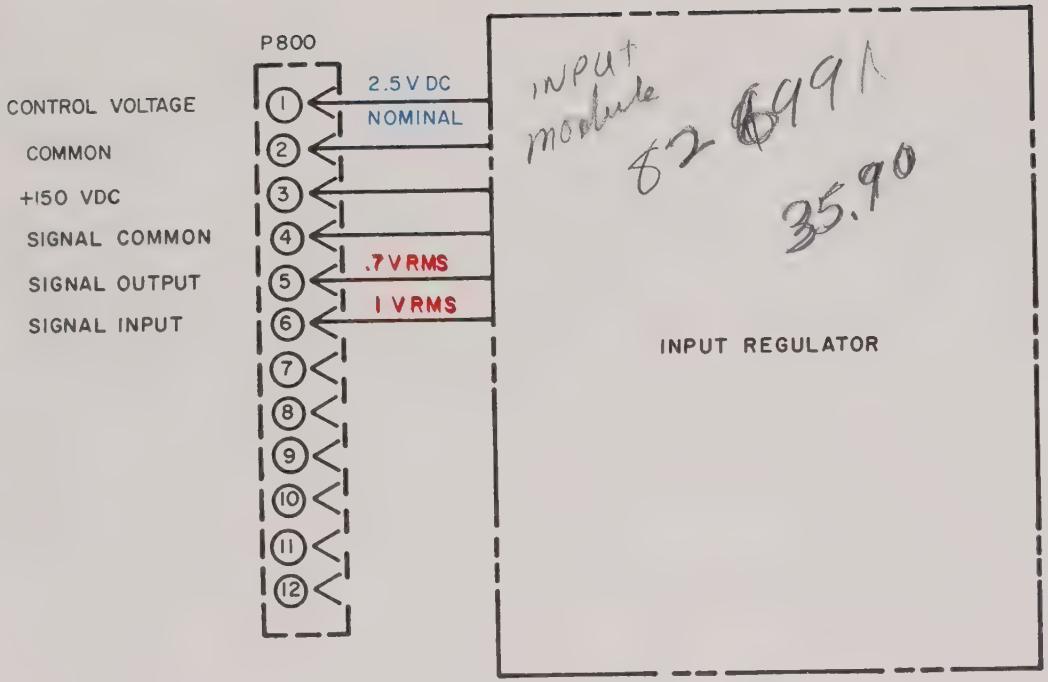
AC/DC CONVERTER

MODEL 323A

HOLT INSTRUMENT LABORATORIES

DOWNER'S GROVE, ILLINOIS


P400
DC SIGNAL INPUT
CONTROL VOLTAGE
PRECISION REF. VOLTAGE IN
COMMON
PRECISION REF. RET.
PRECISION REF. SHLD
115 VAC LINE NEUTRAL
8.3 VAC CHOPPER DRIVE
6 VDC COMMON
+6 VDC
+250 VDC
OVERLOAD
COMMON
+6VDC
+250VDC
G401
TOP CAP
R402 1.3M
R401 75K
R403 75K
L401 132h
L402 350h
L403 435h
L404 350h
L405 127h
C401 .22
C402 275
C403 .043
C404 35
C405 .35
C406 .043
C407 .275
C408 .22
C409
5 VDC
R404 100K
G401A
C410 .006
C411 5
R408 100K
P400 PIN 12
P400 PIN 10
P400 PIN 9
R405 1V SET LEVEL
R406 10K
R407 100K
+250V
R409 22K
C412A 20
R410 221K
R413 1M
C413 .003
C414 1.0
V401 6267
CR401 IN628
R411 1M
R412 2.21K
R414 1M
R416 1K
R415 220K
C415 .01
V402A 12AX7
CR402 IN628
CR403 IN628
V402B
R417 1M
R418 220K
R419 3.3K
C416 .22
V403A 12AT7
R420 1M
R421 1K
R422 22K
C417 22
CR404 IN628
+6V
R423 12K
C418 50
R425 4.7K
R424 33.2K
R426 2.2K
Q402 2N327A
Q401 2N327A
P400 PIN 2
R427 220
R428 1M
C419 .5
R429 1.8K
Z401
CR405 IN628
R431 82K
R433 100K
C412B 20
R432 39K
+120V
C420 .5
V404A 7199
+60VDC
R434 1.5K
R435 39K
R430 1M CONTROL AMP GAIN ADJ.
R437 56K
C421 .5
V404B
R439 1M
R440 1M
G401B
C422 .5
R436 1M
R438 56K
R441 10K
R442 120K
R443 1.2M
C423 40
C424 40
R444 4.7K
R445 10M
R446 100K
V403B
Q403 2N1302
R447 39K
R448 FILTER LEVEL ADJ. 50
R449 12
P400 PIN 13 +2.5 VDC NOMINAL
+ 30v
20
10
0
10
20
- 30v
0
25
50
MSEC
*MAXIMUM VOLTAGE WHEN OVERLOAD LIGHT IS ON.
+6v
4
2
0
2
4
-6v
NORMAL ERROR VOLTAGE WHEN REGULATING
P400 PINS
P400 PIN 5
V401
V402
V403
V404
* WHEN OVERLOAD LIGHT IS ON
EFFECTIVE SERIAL NO 14078
SCHEMATIC DIAGRAM
CONTROL AMPLIFIER
MODEL 323A
HOLT INSTRUMENT LABORATORIES



INPUT module 82-6991 35.90

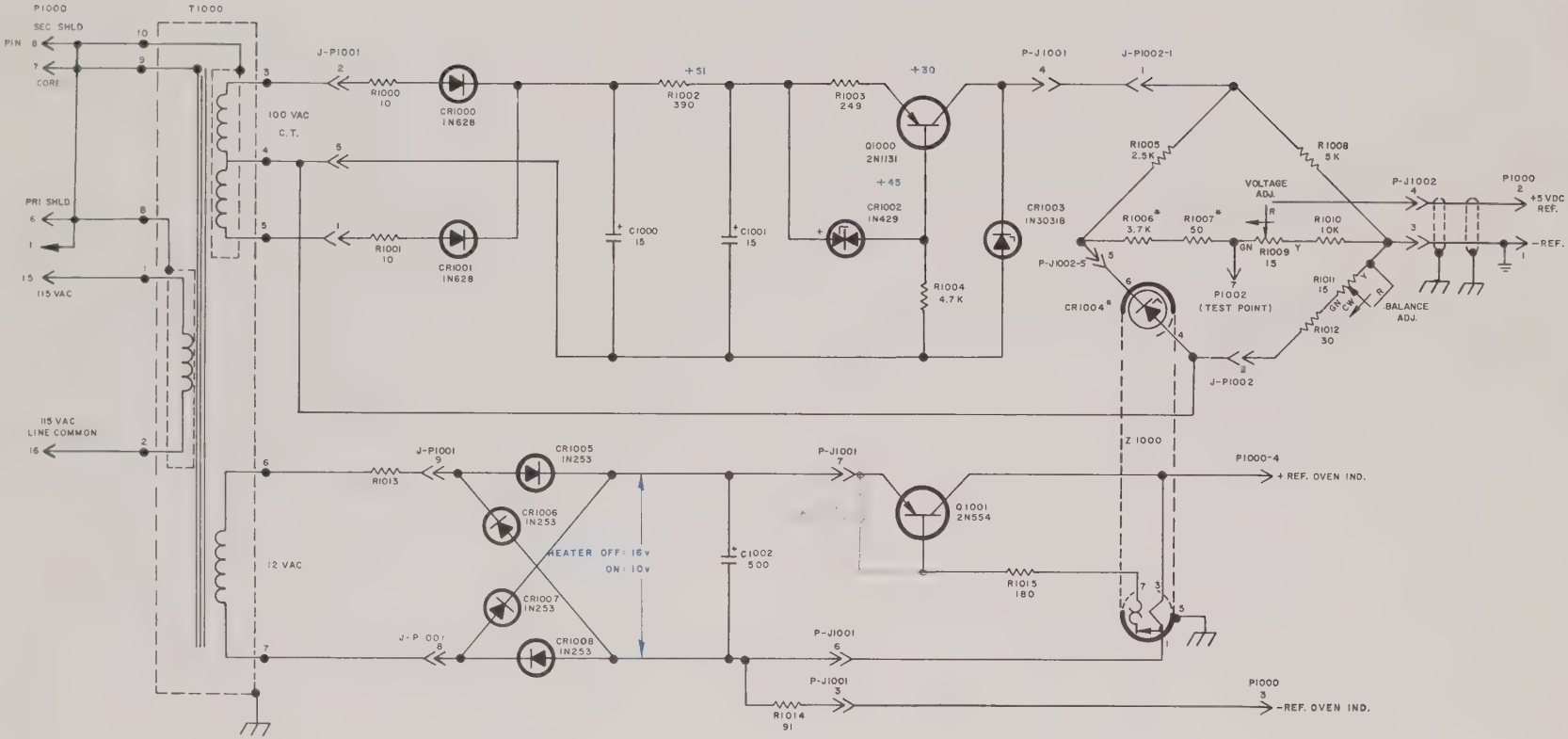
LPD BNG
Box 230
OCONTO WISCONSIN
54153

EFFECTIVE SERIAL NO. 14026

SCHEMATIC DIAGRAM

INPUT REGULATOR

HOLT INSTRUMENT LABORATORIES



NOTE

*FACTORY SELECTED VALUE, NOMINAL VALUE SHOWN

ALL RESISTOR VALUES IN OHMS

ALL CAPACITOR VALUES IN MICROFARADS

UNLESS OTHERWISE SPECIFIED.

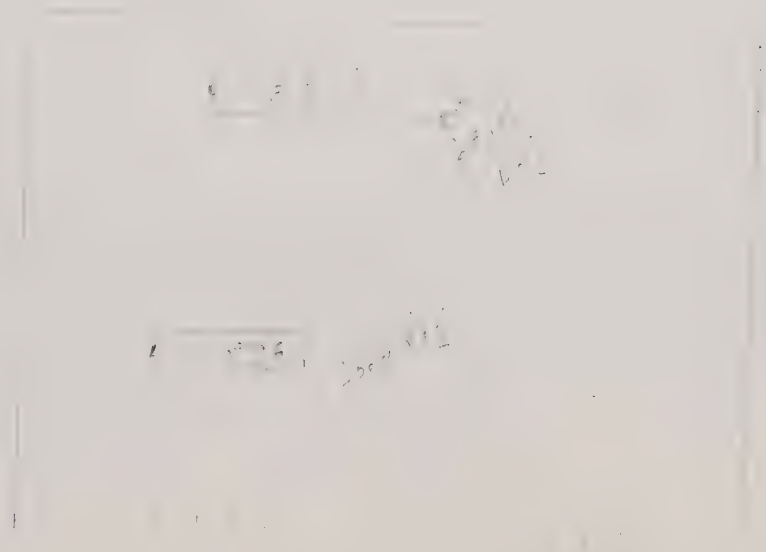
EFFECTIVE SERIAL NO 14078

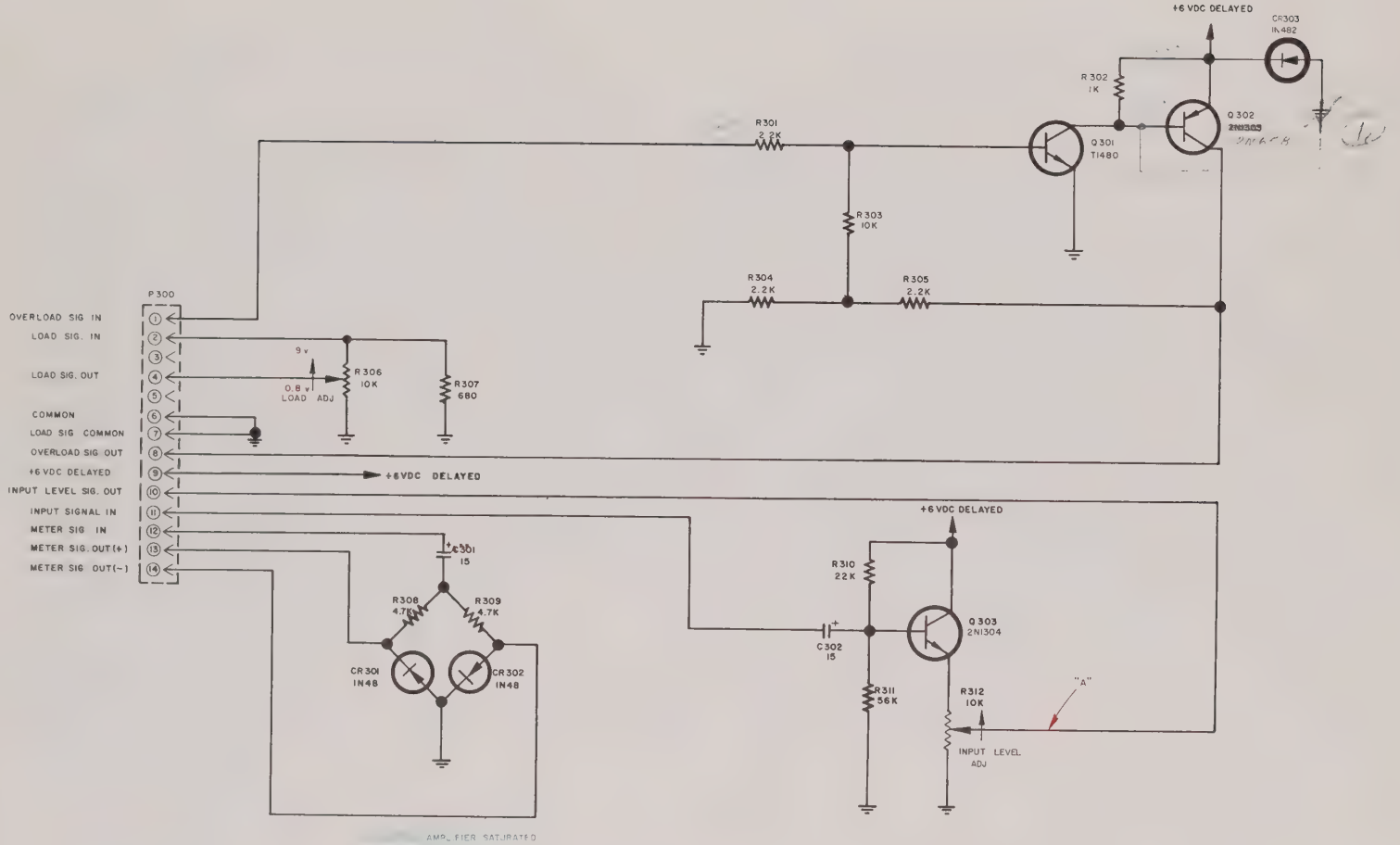
SCHEMATIC DIAGRAM

REFERENCE SUPPLY

MODEL 323PS

HOLT INSTRUMENT LABORATORIES



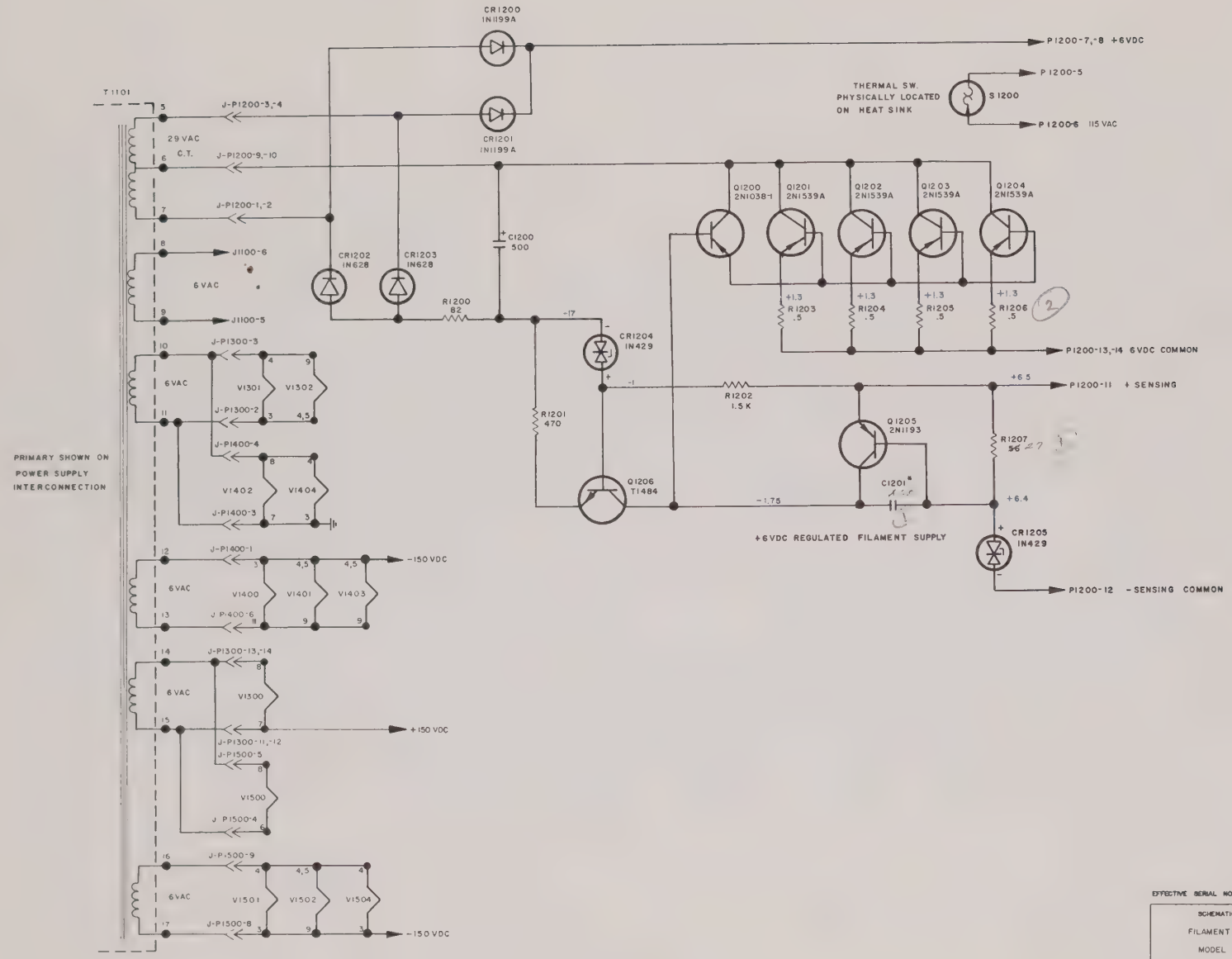


"A" VOLTAGE VARIES WITH "PRESS TO CHECK INPUT" BUTTON
BUTTON NOT PRESSED: 2.1 v
BUTTON PRESSED: 1.4 v

NOTE:
ALL RESISTOR VALUES IN OHMS
ALL CAPACITOR VALUES IN MICROFARADS
UNLESS OTHERWISE SPECIFIED

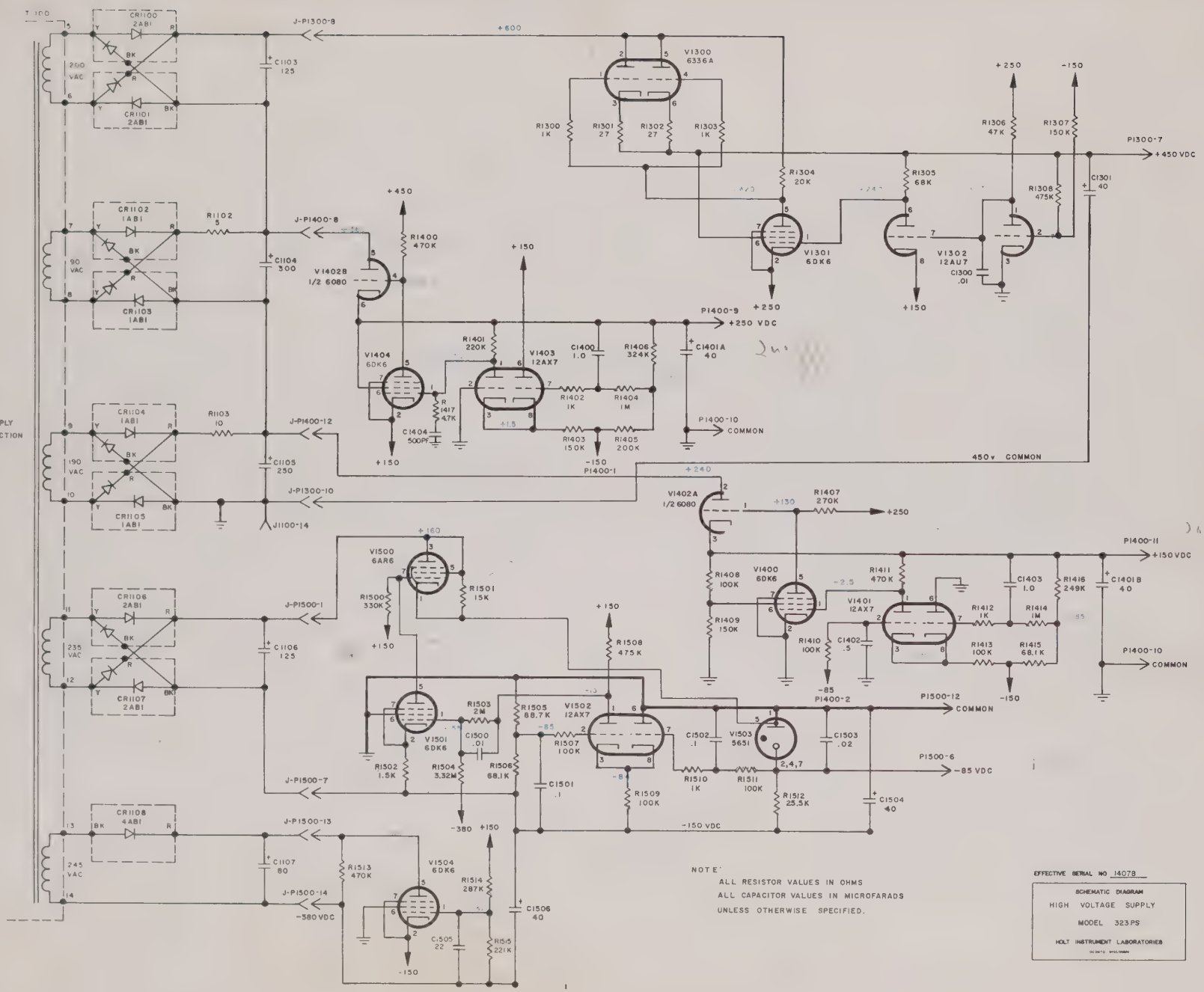
EFFECTIVE SERIAL NO. 14078

SCHEMATIC DIAGRAM
METER
MODEL 323A
HOLT INSTRUMENT LABORATORIES



EFFECTIVE SERIAL NO 14078

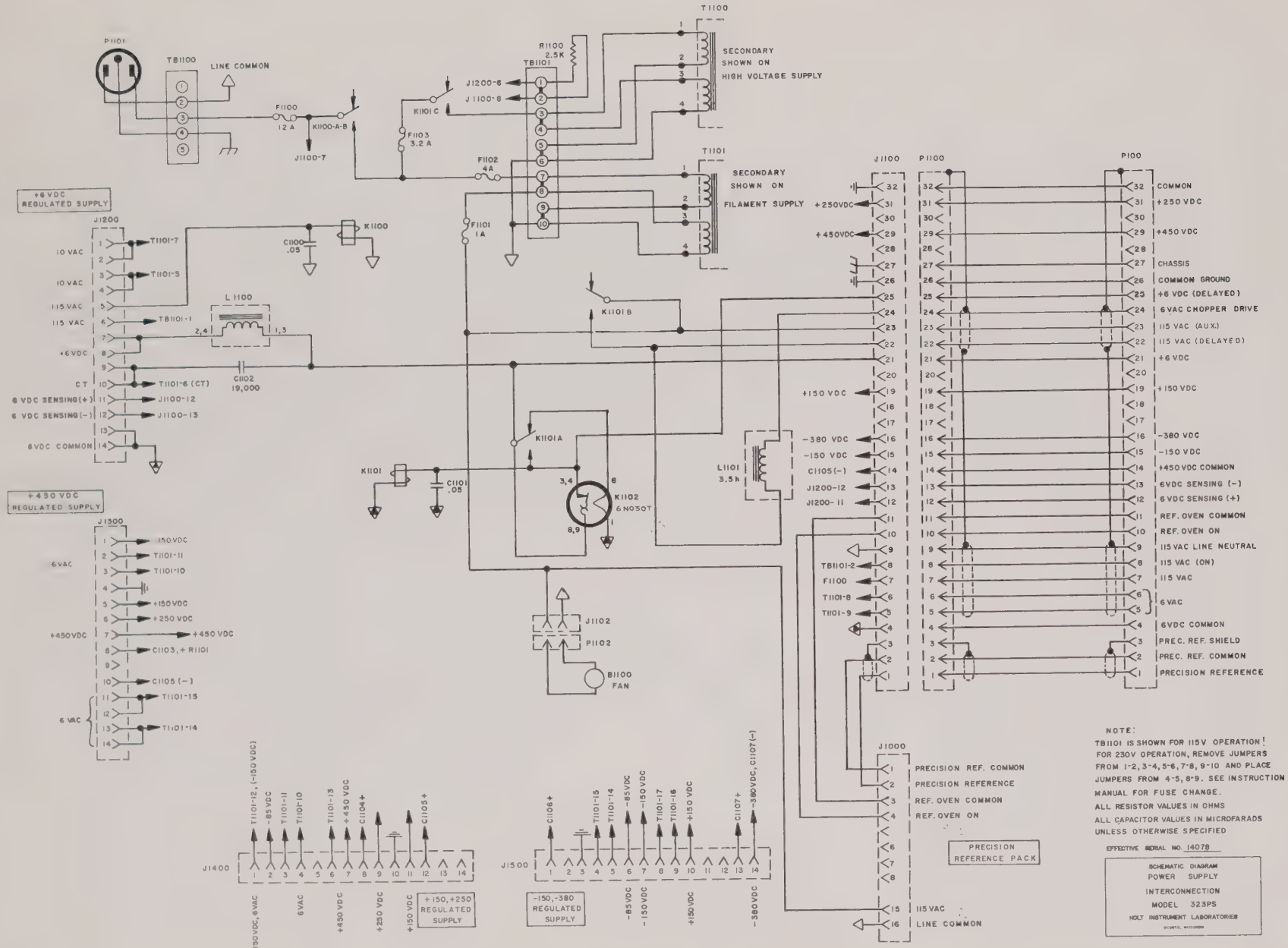
SCHEMATIC DIAGRAM
FILAMENT SUPPLY
MODEL 323PS
HOLT INSTRUMENT LABORATORIES



NOTE:
ALL RESISTOR VALUES IN OHMS
ALL CAPACITOR VALUES IN MICROFARADS
UNLESS OTHERWISE SPECIFIED.

EFFECTIVE SERIAL NO 14078

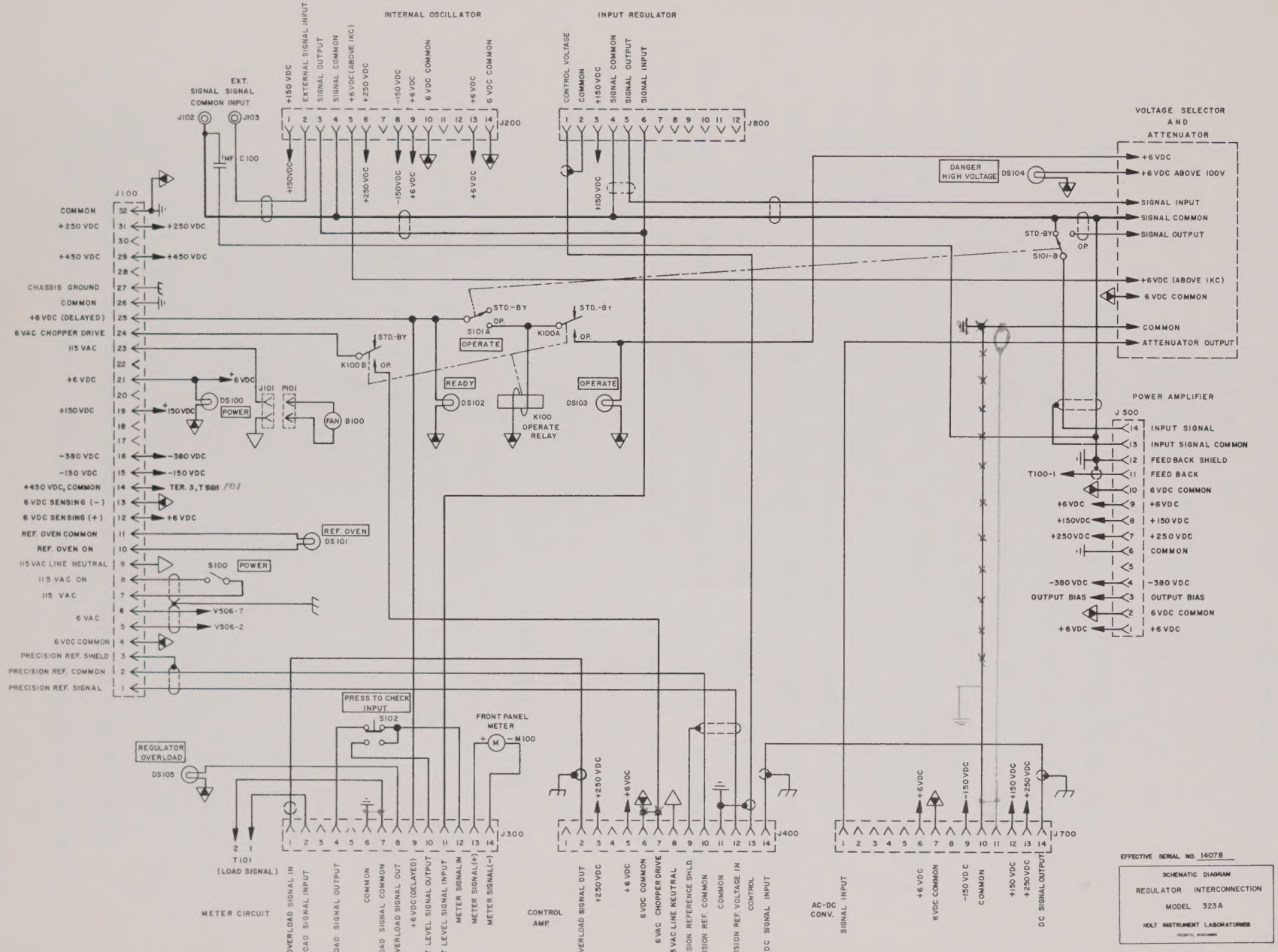
SCHEMATIC DIAGRAM
HIGH VOLTAGE SUPPLY
MODEL 323PS
HOLT INSTRUMENT LABORATORIES
OCONTO WISCONSIN



NOTE:
TB1101 IS SHOWN FOR 115V OPERATION!
FOR 230V OPERATION, REMOVE JUMPERS
FROM 1-2, 3-4, 5-6, 7-8, 9-10 AND PLACE
JUMPERS FROM 4-5, 8-9. SEE INSTRUCTION
MANUAL FOR FUSE CHANGE.
ALL RESISTOR VALUES IN OHMS
ALL CAPACITOR VALUES IN MICROFARADS
UNLESS OTHERWISE SPECIFIED

EFFECTIVE SERIAL NO. 14078

SCHEMATIC DIAGRAM
POWER SUPPLY
INTERCONNECTION
MODEL 323PS
HOLT INSTRUMENT LABORATORIES


INTERNAL OSCILLATOR
INPUT REGULATOR
EXT. SIGNAL COMMON INPUT
J102
J103
1MF C100
J200
J800
J100
VOLTAGE SELECTOR AND ATTENUATOR
DANGER HIGH VOLTAGE
DS104
STD-BY
OP.
S101-B
S101-A
K100-A
K100-B
OPERATE
READY
DS102
DS103
K100 OPERATE RELAY
POWER AMPLIFIER
J 500
T100-1
DS100 POWER
J101
P101
FAN B100
S100 POWER
REF. OVEN DS 101
V506-7
V506-2
PRESS TO CHECK INPUT
S102
FRONT PANEL METER
M100
REGULATOR OVERLOAD
DS105
J300
J400
J700
T101 (LOAD SIGNAL)
METER CIRCUIT
CONTROL AMP.
AC-DC CONV.
EFFECTIVE SERIAL NO. 14078
SCHEMATIC DIAGRAM
REGULATOR INTERCONNECTION
MODEL 323A
HOLT INSTRUMENT LABORATORIES